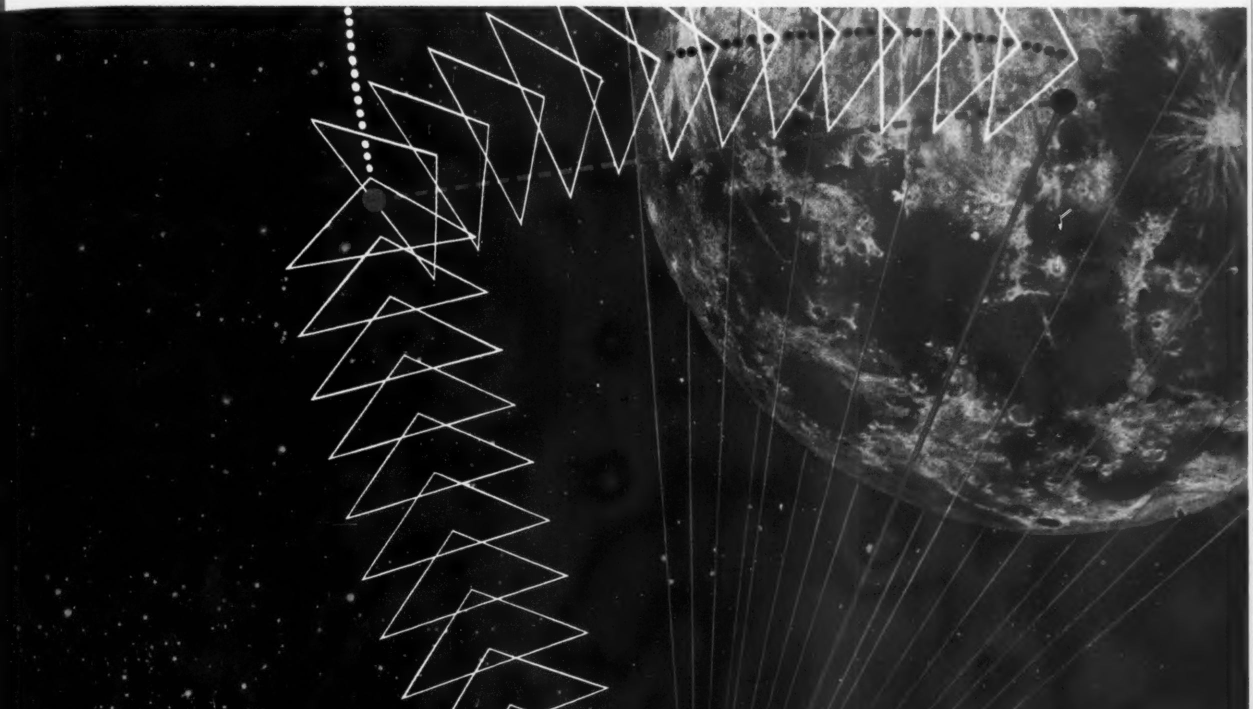
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

SEPTEMBER 1960



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A PUBLICATION OF THE AMERICAN ROCKET SOCIETY INC

September 1960 volume 5 number 9

EDITORIAL

FEATURES

ASTRONAUTICAL REPORT—PART V

ARS NEWS

DEPARTMENTS

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Astro notes

MAN IN SPACE

• NASA will shortly request system design studies for "Project Apollo," to follow Mercury as the U.S. program for manned exploration of space. Objectives of Apollo range from an orbiting space laboratory to a three-man circumlunar flight. Basic vehicle of the Apollo program will be the C-1 and C-2 Saturns. NASA will formally request Apollo funds in its fiscal 1962 budget and plans to award a systems contract for design and construction of hardware in fiscal 1962.

• Heart of Apollo is the command and control center module which will house the crew during launch and re-entry as well as serve as flight control center. It must have the ability to re-enter at escape velocity (36,000 fps) as well as satellite speeds, so that it may serve on both orbiting and circumlunar missions. It must have some maneuvering capability to remain within its permissible flight corridor during re-entry, but a final parachute descent is acceptable. Based on the assumption that Mercury will prove man can indeed perform useful functions in space, NASA plans to leave primary flight control onboard.

• The two remaining modules of the Apollo complex are the propulsion and mission sections. The propulsion module is basically an outgrowth of the Project Mercury escape tower, to be used in case of an abort during launching, but it would also initiate return from orbit as well as course corrections. The mission modules will vary widely depending upon the goal of the flight. For circumlunar missions, the module would carry only limited scientific instrumentation and life-support systems sufficient for about one week; for an earth-orbiting laboratory, on the other hand, the module would carry extensive instrumentation and life support for up to two months. In either case, however, the module would be required to provide a "shirtsleeve" environment at all times for the three-man crew.

• NASA said the flight-test program for the Apollo spacecraft is scheduled to start in 1962 and end in 1965. Early flights using the Atlas-Agena-B will verify final design criteria for the shape of the Apollo and its heat protection. The Saturn will be used for full-scale development and test flights, possibly as early as 1963 when the first all-live Saturn boosters are flight-tested at Cape Canaveral. Earth orbital missions for Apollo may begin in 1966, with circumlunar missions following as soon as technical and aeromedical knowledge permits.

• An Atlas malfunction 65 sec after launch spoiled NASA's first flight test of the McDonnell production capsule for the Mercury program. The capsule was not equipped with the escape tower which will be standard equipment on later flights. Purpose of the shot was to test the structural integrity of the capsule during a maximum abort re-entry. Critics of the Mercury program warned that the failure may be disastrous to U.S. chances of sending the first man into space, but Space Task Group officials at Langley, Va., insisted that the loss of time would only be two or three weeks. The House Science and Astronautics Committee early next year plans to investigate the Mercury program delays.

• NASA's Ames Research Center is building two major simulators for the Mercury project. One is a five-degree-of-freedom centrifuge for testing the pilot's ability to control re-entry vehicles up to 6 or 7 g. The other is a full-scale space orientation-control simulator consisting of a 9-ft sphere mounted on air bearings with complete rotational freedom. It will test the problem of manned control of undamped vehicles in space.

• Avco is making another attempt to win an AF contract for its drag-brake manned re-entry satellite, possibly as back-up for Project Mercury. This time Avco has some good ammunition, a classified study of the subject by one of the leading airframe manufacturers which lists the drag-brake vehicle as the lightest and simplest which could be produced.

• Although slow rotation of a space vehicle will provide the advantage of a simulated gravity, it may also cause disasterous effects in an astronaut—nausea, vomiting, vertigo, and general discomfiture. (The danger of vomiting in space is particularly acute, as vomit could easily strangle an astronaut.) The Navy's studies of men riding the "rotating room," a 13-ft-diam chamber on a 22-ton centrifuge at the Pensacola School of Aviation Medicine, show that the least movement brings the onset of these responses, in various degrees of force depending on the individual. The Navy will use the rotating room to evaluate the effects of slow rotation on men, to grade subjects according to their responses, to identify clearly the phenomena of disturbance, and to find drugs that will counteract or prevent disturbances (in this connection, see page 26). At the same facility, the Navy has a "cement mixer" for spinning a man in combinations of rotations, with rates from $^1/_{10}$ to 300-deg arc per second, to study his response to disorientation.

X-15

• NASA test pilot Joe Walker became the fastest man in the world by driving the X-15 to a speed of 2196 mph with its interim powerplant. He eclipsed the old mark of 2094 mph set in 1956 by Capt. Milburn Apt in the X-2 flight which subsequently killed him. Capt. Bob White, USAF, soon afterward established a new altitude mark, by taking the X-15 to 136,500 ft. Previous record of 126,000 ft was set by the late Capt. Iven Kincheloe in the X-2.

• NASA expects delivery of a full-power X-15 in November. This will have an XLR-99 rocket motor of 60,000-lb thrust. Flights to Mach 6 and altitudes of 250,000 ft are expected late this year or early in 1961. This is about three to six months behind the original schedule because of the recent explosion in X-15 fuel-tank system.

SPACE TECHNOLOGY

• NASA will follow up its Ranger series of lunar "rough landers" with two new series of unmanned scientific probes. The first is Surveyor, a 100 to 300-lb spacecraft based on the Centaur vehicle and capable of a soft lunar landing. NASA expects to pick a hardware contractor for this system early next year. The successor system, designated Prospector, will utilize the Saturn launching vehicle. Prospector will consist of a standard soft-landing "truck" plus a variety of payloads including a mobile laboratory with an exploration radius of 50 miles.

• For interplanetary probes beyond the Pioneer series, NASA is planning Project Mariner for early missions to Mars and Venus, followed by Project Voyager using the Saturn vehicle to place payloads in orbit around these planets and to eject instrumented capsules for atmospheric re-entry and possible landing. It is hoped that the interplanetary payloads will evolve directly from the lunar payloads, thus minimizing cost. NASA's Jet Propulsion Lab will direct both lunar and interplanetary explorations.

• NASA has announced the appointment of Dr. S. J. Gerathewohl as chief of operational development for its Life Science Program, under the direction of Dr. Clark T. Randt. Dr. Gerathewohl, 50, is noted for his experiments into the effects of weightless flight. NASA also appointed Dr. Richard S. Young, 33, to the post of chief of flight biology. He formerly directed space biology experiments for ABMA.

• The Naval Research Lab reported a successful Aerobee flight to 90 miles' altitude from White Sands, N.M., with an experiment which achieved the most detailed measurements of solar ultraviolet radiation in the 2000–3000 angstrom region conducted to date. The experiment included a pointing control devised by Aircraft Armaments, Inc., Baltimore, to hold the sun's image on the spectroscope.

• NASA is making stellar and solar observations with Aerobee 150A's launched from Wallops Island. The 150A packs a 160-lb payload to an altitude of about 150 miles. More than a half-dozen have been launched to date, and several more will be sent aloft in the coming months. The all-weather sounding-rocket complex at Wallops was designed and constructed for NASA by Aerojet's Aetron Div. It features a launching boom similar to the Army one at Ft. Churchill.

• Raytheon is studying ways to improve active Doppler velocity sensors for use in soft-landing space vehicles under contract to ARDC. . . . Collins Radio will study radio communication problems in conjunction with McDonnell's study for JPL on soft-landing instruments on the moon . . . TRW's Dage Television Div. will manufacture a television camera and transmittter that will fit into the nose cone of the Arcas sounding rocket (4.5 in. in diam), and descend by parachute, sending pictures of weather, ocean conditions, ships at sea, etc. It will be expendable, and replace expensive movie systems costly to recover . . . Beckman Instruments' Systems Div. will produce two high-speed data-processing systems (Pice) for Lockheed under a $1.1 million contract; the systems will control data flow between satellites and earth stations . . . Basic research in evaluating biological effects of cosmic radiations will be done by Controls for Radiation Inc. under contract with the AF Missile Development Center of ARDC. Biological specimens to be studied will be representative of the types of cells in animals and humans. They will be subjected to particle bombardment by cyclotrons and linear accelerators.

• Worldwide communications through satellite systems—a rapidly advancing space technology—appears to be forcing the government toward some action on major unresolved problems of the Space Age: How to institute worldwide industries based on space research; what policy to form on international space law; and how further to develop the nation's administrative functions in these areas. The Project Echo communications experiment brings these problems to the level of immediate practical concern, if other events of the past three years have not. Bell Telephone Labs conducted the first two-way voice communication via the moon in anticipation of the Echo experiment, using for reception their three-level traveling-wave maser and a 50-ft horn antenna, which together have the exceptionally low noise temperature of 25 K. This equipment is ready for extensive use, although, of course, there is yet no satellite system as proposed recently by AT&T, parent company of Bell. Yet it underscores the significance of ATT arguments before the FCC that frequency allocations above 890 mc are needed soon for space communications. This proposal alone confronts the government with domestic and international problems of moment.

TIROS

• The unparalleled success of the Tiros I meteorological satellite has convinced the AF that "real time" weather information can be obtained from satellites much earlier than planned. When Tiros II is launched in October, the Air Weather Service will be ready to incorporate its pictorial data immediately into its facsimile system for distributing weather charts.

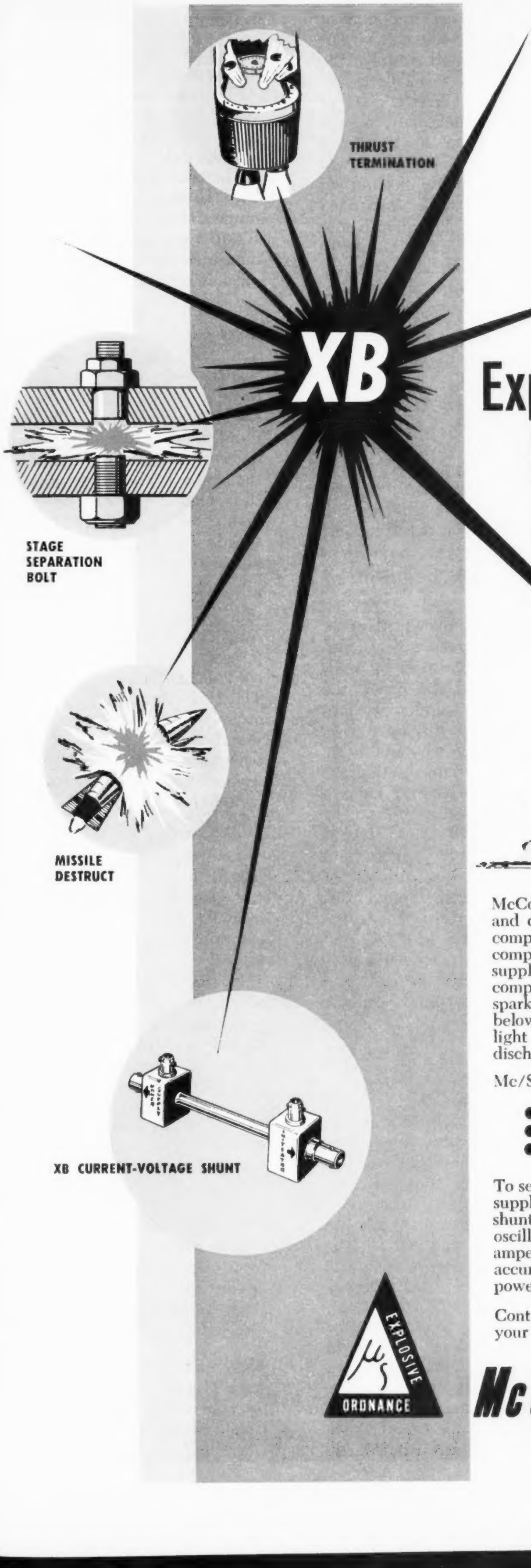
• Tiros I definitely spotted a tornado storm system during its period of operation, according to the Weather Bureau. On May 19 it photographed a bright "square" of isolated cloud in the vicinity of Wichita Falls, Tex., about two hours before violent tornadoes and hailstorms broke out in this area along the Texas-Oklahoma border. Weather Bureau officials emphasized that the tornado discovery by Tiros was a "stroke of luck" and that not every isolated cloud mass detected by a weather satellite will warn of severe weather.

• Project Nimbus, a 600 to 700-lb meteorological satellite, will ultimately succeed Tiros. It will be equipped with a greater variety of sensory apparatus, including simplified radar to observe rainfall, a spectrometer to measure temperature, and an image orthicon to map night cloud cover. Beyond Nimbus, NASA is thinking of Project Aeros. This is a system of three Centaur-boosted satellites in stationary, earth-period orbits. Such satellites could view most of the earth's surface continuously. NASA said it might start Aeros as a hardware program in 1962, with a launching in 1964.

PROPULSION

• NASA gave $100,000 contracts to The Martin Co. and Lockheed Aircraft Corp. to produce studies of requirements for a nuclear-rocket flight-test program. The studies will include system preliminary design, development programming, planning of test and tracking facilities, schedules and safety factors. The biggest question still relates to the way a nuclear rocket will be flight-tested: From the ground, as the second stage of a chemical rocket in a short ballistic trajectory, or as the orbital-start stage of a Saturn vehicle. The latter procedure would minimize terrestrial radiation danger, since the nuclear stage would not be activated until a stable orbit was assured.

• With 1965 as the goal for flight testing the first solid-core nuclear rocket, NASA will have its hands full solving the engineering problems presented by the non-reactor portions of the system. Some of the requirements:—Lightweight insulation that can be bonded to the walls of the liquid hydrogen tank to hold it in liquid condition, prechilling techniques to permit the hydrogen tank to be filled without collapsing, pressurization to prevent sloshing of the hydrogen,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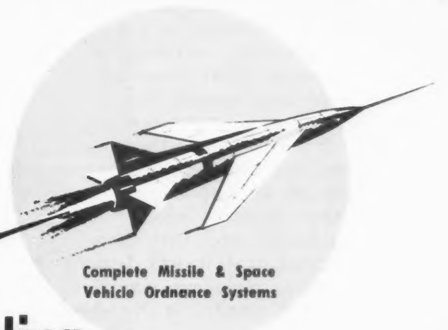
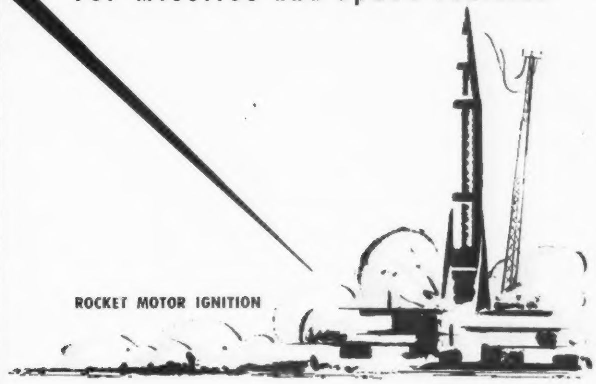

Complete Missile & Space
Vehicle Ordnance Systems


ROCKET MOTOR IGNITION

which is only 1/15 the density of water, and a nozzle which will transfer heat at twice the rate of current chemical rockets.

• NASA has not yet ruled out liquid fluorine-liquid hydrogen as a propellant combination. It notes that the combination offers potentially 40 per cent more specific impulse than hydrogen and oxygen, but admits that it is not clear whether this can be realized in practice. And then there are the handling problems. "One company which has done considerable work with fluorine has stated that it will burn with anything, including pumps, seals, and test stands," a NASA official observed.

• Rocketdyne Div. of North American has developed a technique for tapping the rocket thrust chamber for the hot gases necessary to drive a turbopump, thus eliminating the need for a separate gas generator. Starting requirement is met by a solid-propellant spinner to get the pump going. Rocketdyne has demonstrated the feasibility of the tap-off technique in 64 tests of a modified MA-2 sustainer motor.

MISSILES

• The Navy selected Douglas Aircraft to develop the Missileer aircraft for launching the 100-mile range Eagle air-to-air defensive missile. The subsonic aircraft will be powered by two Pratt & Whitney TF30 turbofan engines and will be capable of carrying six of the long-range missiles while flying interceptor cover for naval carrier forces. It was reported that the Navy may ultimately buy 120 Missileer aircraft at a total cost of $600 million, but the Navy refused to confirm the report.

• The last major objective in the Navy's pell-mell Polaris development program toppled in July when the George Washington nuclear submarine successfully fired three Polaris missiles while submerged. The missiles traveled 1100 miles down range. (A fourth underwater shot from the submerged submarine was destroyed by the safety officer when it veered off course 47 sec after launch.) The George Washington and a sister submarine are scheduled to assume operational stations by the end of this year with a magazine of 16 missiles each.

• The first Polaris operational missiles will have a range of 1200 n.mi. and will be installed in the first five Polaris submarines to be built. The next five missile submarines (the Ethan Allen class) will receive 1500 n.mi. Polaris missiles, the first of which will be flight-tested this year. Aerojet reports static-testing the motor for the 1500-mile Polaris successfully. The Lafayette class of ballistic missile submarines, to commence construction in the fiscal 1961 shipbuilding program, will presumably be capable of handling the 2500 n.mi. Polaris authorized for development by President Eisenhower in August. The Lafayette will be 425 ft long and will displace about 7000 tons, thus becoming the Free World's largest submarine.

• The Army will commence flight tests early next year of a tactical-type Nike-Zeus anti-ICBM missile from Point Mugu, Calif. The weapon will be tested over its maximum range using the Western Electric-Bell Telephone command guidance system. The anti-missile will later be tested at Kwajalein against Atlas ICBM's fired from Vandenberg AFB, Calif., a distance of 4800 miles.

• The Army announced plans to equip its major forces with a long-range surveillance drone by mid-1964. Designated the SD-5, the 8500-lb craft is now under development by Fairchild Engine & Airplane Corp. Powered by a 3000-lb-thrust Pratt & Whitney J30 engine, the craft is estimated to have a speed of about 600 mph and a range of 1000-1200 miles. It will perform photographic, radar, and infrared missions in support of Army groups. More limited missions will be performed by the short-endurance Aerojet SD-2 and the medium-endurance Republic SD-4. The Army's present surveillance drone is the Radioplane SD-1.

• The AF picked GE's Missile and Space Vehicle Dept. to develop the re-entry vehicle for the Titan II ICBM. The new vehicle may utilize information produced by a new re-entry test program based on GE's RVX-2A nose cone. Four of these will be launched by Atlas missiles, two with GE ablation materials and two with Avco materials. The RVX vehicles will use recovery systems developed by Cook Electric Co.

• Martin Co. made it six straight successes with the Pershing in July, when it launched the two-stage bird from the transporter-erector-launcher mounted on a tracked vehicle. Shortly afterwards, Martin received $30 million in additional Pershing contracts.

• The AF will install Bomarc-B interceptor missiles at McGuire AFB, N.J., and Otis AFB, Mass. Each will receive 28 of the weapons, which will have a range of 400 miles. McGuire now has 36 Bomarc-A missiles, and Otis has 28. These are limited to 200-mile range. Assignment of the Bomarc B's to the northeastern U.S. is an outgrowth of revisions ordered in air-defense plans early this year.

• Continuing to further the feasibility of a ballistic missile defense system, the Army reported that the Raytheon-developed Hawk successfully intercepted and destroyed a Little John in flight. The feat was significant because of the small radar cross-section of the Little John, the Army said. It measures 14.5 ft in length and just over 1 ft in diam. The relative intercept speeds and angles, however, were not reported.

• The Army set up a Ballistic Missile Construction Office in Los Angeles last month to expedite the program for construction of intercontinental ballistic missile sites. The new office will supervise $680 million worth of Atlas and Titan squadrons now under construction, plus another $350 million of additional Titan and Minuteman sites included in the fiscal 1961 appropriation.

• The AF briefed vendors last month on its new prequalifying test program for equipment to go into Titan II's propellant transfer system, which will be based on loading-unloading equipment movable from launch site to launch site. Titan II will use a mixture of hydrazine and UDMH as fuel and nitrogen tetroxide as oxidizer. Only components which pass the prequalifying tests will be considered for contracts, according to the AF. Critical components include valves, pumps, meters, filters, and various instruments, such as liquid-level sensors.

• A Titan I propelled by its new-model engines failed in a flight from Cape Canaveral late in July, apparently from a premature first-stage shutdown. The missile traveled 80 miles.

• Competing test versions of third-stage Minuteman engines produced by Hercules Powder and Aerojet-General have now been static-fired

(CONTINUED ON PAGE 13)

successfully in an altitude-simulation chamber of Arnold Engineering Development Center. These were the largest solid-propellant rocket motors ever fired in an altitude-simulation chamber in the U.S. The tests led to the selection of the Hercules design for production.

• The Atlas which flew some 7000 miles from Cape Canaveral to just off the southwest coast of Africa August 9 carried about 1000 lb of instruments as a payload and produced "additional data on heating and ablation of the nose cone." The missile reached an altitude of 1000 miles.

R&D

• The proceedings of the NASA-Industry Program Plans Conference, held July 28–29 in Washington, D.C., suggest that companies are entering one of the most important periods of industry competition in the history of our country these next two years—the period of major proposal making in the national space program. The NASA brochure on this meeting, out already and available from its offices, is "must" reading. Follow-on conferences take place at Marshall SFC on Sept 27–28 and at JPL on Oct 26.

• Reflecting the formative powers of a new era, Aerojet-General announced the establishment of a Spacecraft Div. at its Azusa, Calif., plant, as an outgrowth of its Systems Div. established in 1958. M. L. Stary will manage Spacecraft. . . Rocketdyne's new Electrical Propulsion Lab entails facilities for advanced work on ion, colloid, and plasmajet engines; associated power supplies; and propellant feed systems, controls, and instrumentation . . . Northrop's present 85-ft zero-g tower, which is part of its Space Physics Lab, is expected to lead to a 400-ft tower for zero-g testing both organic and inorganic materials.

• Hughes Aircraft will study and develop a material for lining large solid-rocket motor cases under a $200,000 Army contract. A two-year program, this will include an examination of the missile and rocket industry's present research on lining materials . . . Nuclear Development Corp. of America will investigate special methods for thermal protection of solid-rocket nozzles, principally sweat cooling, under Army contract with a $67,700 first-phase of experimental demonstrations . . . Studies of low-drag boundary-layer control related to integration of structural and propulsive methods will be made by Northrop under a new $950,000 contract with ARDC as an extension of work begun in 1952.

• North American Aviation will demonstrate a generator and distribution system designed to operate at ambients from −65 to 600 F this month. . . Good progress is being made by GE's Light Military Electronics Dept. on a liquid-metal power-transmission test loop that circulates NaK-77 at 3000 psi and 1000 F . . . Avien Inc. announced the development of an underwater propulsion system with an exhaust-gas compressor capable of operating under pressures of 3200 psi (i.e., down to 7000 ft).

• TRW's Pacific Semiconductors subsidiary has developed a 1-watt, 1000-mc solid-state power generator for telemetry and space communication systems . . . Under an initial contract for $1.3 million, Sperry Gyroscope will develop a superpower klystron for Nike-Zeus radar . . . Bulova Watch is developing a recording camera with unique optics for the AF under a $198,000 contract.

• An automatic machine, powered by a 5-watt Strontium-90 nuclear generator, will be developed for the AEC by the Martin Co. to record and transmit data in remote places for periods of at least two years. As a demonstration run, the machine will be linked with weather instruments, but it will be easily modifiable for taking and transmitting seismic readings and other measurements likely to be made in an isolated place.

CONTRACT BRIEFS

• The Navy awarded $28 million in contracts to Northrop for Polaris work—development and production of automatic checkout systems (based on the Northrop-developed digital automatic tape Datico concept), gyroscopes, Type-II periscopes, radiometric sextants, etc . . . The NASA-Douglas contract for production and testing of 10 C-1 Saturn second stages (S-IV) was formally approved and signed; cost of the program will amount to about $65 million . . . The NASA George C. Marshall Space Flight Center issued some $20.5 million in one-year contract extensions on Saturn, Juno II, and Mercury-Redstone launch-vehicle programs.

• Western Electric received the $18 million in contract funds squeezed out by the Army to push work on Nike-Zeus: $11.34 million for development and proof-testing of high-volume manufacturing and inspection techniques, special tooling, and test equipment and facilities for certain critical components; and $6.66 million for development of advanced techniques for production of electronic components.

MATERIALS

• In a symposium at the ASTM's recent Annual Meeting, Harvey Brooks of Harvard Univ. made these interesting comments on materials research: "Ideally, we would like to be able to solve the complete wave equation for a collection of nuclei and electrons and predict all the crystalline properties, including the most stable crystal structure. This the extreme of a theory from 'first principles.' We are very far from such a theory, even in the simplest cases."

• Under Project Pontus, ARPA recently gave an impetus to long-range and stable research on materials by providing funds for materials research centers at Cornell ($6.1 million), the Univ. of Pennsylvania ($4.4 million), and Northwestern ($3.4 million). These initial funds run for four years. Eventually ARPA expects to support materials research in universities at $17 million annually.

• Spherical-particle powders of copper, aluminum, nickel, 316 stainless steel, tungsten, and nichrome have been produced by the Linde Co. in sizes from 20 to 150 microns with a uniformity rate of 98 per cent. According to the company, the particles are free of voids, cavities, and inclusions.

ROBERT H. GODDARD—IN MEMORIUM

• It was coincidence, but as the ARS was dedicating a memorial to Robert H. Goddard at the site in Auburn, Mass.—now a golf course—where he flew the world's first successful liquid rocket on March 19, 1926 (see page 34), the U.S. Government settled for $1 million a patent-infringement claim filed by the estate of Dr. Goddard and the Guggenheim Foundation. Dr. Goddard invented and developed turbopump, inertial-guidance, and other equipment for rockets. The settlement was allocated among government agencies as follows: Air Force, $765,000; Army, $125,000; Navy, $10,000; and NASA, $100,000.

For the record

The month's news in review

July 1—Tracking failure causes NASA to abort Scout just before fourth-stage ignition.

July 2—House Space Committee report calls NASA space program shortsighted, urges top priority be given to manned lunar-landing program and speed-up in development of nuclear-rocket and 1,500,000-lb-thrust single-chamber engines. Report also criticizes Administration for lack of support of Nike-Zeus program, advises DOD to turn over control of Project Orion to NASA.

July 3—Preliminary study at New York Univ. indicates stony meteorites, as might be expected on the moon, can be made to yield rich supply of oxygen.

July 4—U.S.S.R. discloses having sent two dogs and a rabbit in a rocket 130 miles into space and back safely in June.

July 5—Soviets fire multistage test rocket 8078 miles into mid-Pacific.

July 7—Soviets end series of rocket tests in Pacific with 8000-mile shot, which they say impacted "directly" on target.

—Pioneer V radio goes dead, transmitted over nearly 23,000,000 miles.

—Bureau of Mines says its new technique of electrorefining beryllium scrap promises new source for the high-purity metal.

July 8—Soviets report signal equipment on its "space ship" launched into earth orbit May 15 has stopped functioning.

—DOD acknowledges five-month lag in construction of Atlas launching sites.

—Hughes Aircraft scientist, using a laser, claims first true amplification of light.

July 11—Ivan A. Getting, former Raytheon vice-president for research, has been named president of Aerospace Corp., formed to manage AF's missile and space programs.

—Bell Telephone System outlines to FCC plan for worldwide phone and TV network utilizing about 50 satellites in polar orbits.

—RCA announces development of thermionic converter tube with efficiency as high as 14 per cent.

July 13—AF-GE publicly describe Mistram (missile trajectory measurement system) being developed under $15,500,000 AF contract.

—Army launches Strongarm rocket carrying 37 and 148 mc transmitter in nose cone.

July 14—MIT is recipient of $9,500,000 AF basic-research contract for new magnet lab which will include world's most powerful magnet—250,000 gauss.

July 15—AF announces it is building a vertical cell for altitude testing large solid-propellant rocket engines at its Arnold Engineering Development Center in Tenn.

—Navy successfully fires Polaris from underground silo.

July 16—U.S. announces plans for Tiros II in world weather forecasting project to start this fall, advancing the program by about three years due to outstanding success with Tiros I.

July 18—Navy cancels its Corvus project after spending about $80,000,000 on it.

—Robert C. Seamans Jr., former chief engineer, RCA Missile Electronics and Control Div., is named NASA associate administrator.

July 20—Two Polaris missiles successively fired from submerged sub, George Washington, hit target 1150 miles away.

July 23—NASA successfully fires first Iris, single-stage sounding rocket, to 140-mile altitude.

—UK announces development of an image intensifier at Imperial College, London, that multiplies a single photon a million-fold and will enable man to see further into space.

July 28—NASA discloses names of space projects beyond Project Mercury as follows: Apollo, Surveyor, Mariner, Ranger, and Voyager. Deputy Administrator Hugh Dryden releases future plans: 1960, launching of passive-reflector communications satellite and Scout, Delta, and Atlas-Able vehicles, and first suborbital manned flight; 1961, first orbital manned flight, lunar impact, and first launching of Centaur; 1962, launching instrumented probe near Venus and Mars, and two-stage Saturn; 1963–64, unmanned lunar landing and orbiting astronomical observatory; 1965, flight test of nuclear rocket second stage; 1965–67, manned flight around moon and establishment of space station near earth. Then "manned flight to a landing on the moon and return to earth beyond 1970."

—AF Titan travels only 80 miles in 5000-mile test.

July 29—First NASA heat re-entry test for Project Mercury capsule fails when its Atlas booster blows up some 65 sec after blast off.

—NASA schedules construction start of Project Apollo, three-man lunar ship, for 1961.

July 30—Navy successfully fires third Polaris from submerged George Washington sub more than 1000 n. mi.

In print

Man High by Lt. Col. David G. Simons (MC) USAF with Don A. Schanche, Doubleday, New York, 262 pp. $4.50

Rocketship X-15 by Myron B. Gubitz, Julian Messner, New York, 288 pp. $4.95

These two books are related in that they both tell of man and his travels to the edge of the atmosphere in the pursuit of knowledge. "Man High" is an autobiographical account by Lt. Col. David Simons, internationally known for his historic 100,000-ft altitude hop three years ago in a free balloon. Dave Simons is known widely in the space medical fraternity as a competent project officer in bioastronautical research, as well as a friendly, likeable personality. Don Schanche, who assisted Simons in writing the book is one of *Life's* top military and science reporters.

Man High is the operational code name for a space medical research project which commenced in 1955 and was aimed at the detailing of man's living and working requirements under quasi-space conditions. In addition to Simon's 20-mile high flight, those of Capt. Joe Kittinger and First Lieut. Clifton (Demi) McClure are also detailed. The problems encountered with vagaries of the weather, instrumentation, and communications equipment are related in a manner which reflects human fallibility, engaging enthusiasm, and a sense of adventure and excitement. These flights, with the human occupant crammed into a pressure suit within a telephone booth-sized capsule, were dangerous, and a less efficient operation would have resulted in several deaths. As it happened, anoxia, carbon dioxide poisoning, and heat prostration came close to killing the balloonists.

Simons and Schanche not only tell an exciting story but explain the whys and wherefores without pedantry. A good case is made for the high research value of these flights and the importance of the data obtained by the AF Medical Corps for planning and setting specifications of life-support equipment for astronauts. The whole Man High program was founded on a shoestring and included contractor funds supplied by Winzen Research to insure the project's completion. Finally, the reasoning behind technical decisions and analysis of postflight results provide an interesting insight into the thought processes of AF medical researchers. Col. John Stapp, Brig. Gen. Don Flickinger, Otto Winzen, George Ruff, Jim Henry, Rufus Hessberg and other well-known personalities appear in "Man High." The book is recommended for all libraries interested in man in space.

"X-15" is an account by free-lance writer Myron Gubitz of the history and development of this rocket research aircraft. Gubitz has done an outstanding job of digging up a plethora of technical and operational details on the project. The book is divided into two parts. The first, entitled simply, "The Bird," tells of "The Family Tree," "Birth," "Anatomy," and "The Mission." The second part, nearly three-fourths of the contents, is devoted to "The Countdown," detailing three days of checkout and checkoff lists and finally, a powered flight to 95,000 ft.

Much of the material has come from AF and NASA PIO's and PR representatives of the industrial firms involved. By far the most interesting portions to this reviewer were obviously first-hand interviews with the dozens of pilots, engineers, and technicians concerned with the flight-test program. Complete transcriptions of radio communications among the test plane, mother ship, chase plane, and ground communications bring home the excitement and technical sophistication of this research project. The industry-AF-NASA teamwork required to conduct such a project is well brought out but evidence of the inter-service battles for control and funding are missing. Also missing is adequate recognition of the Douglas Aircraft-ONR Air Branch 200-mile aircraft design study under Cmdr. George Hoover's leadership in 1954, likewise planned around RMI's 50,000-lb thrust (Super Viking) engine development. But such knowledge is hard to come by from the outside and its absence may be forgiven.

Overplayed, in the reviewer's opinion, is the importance of the X-15 to space flight. It has yet to be proved that man will come back from space in an airplane. The weight penalty for winged lift is so high in the light of orbiting payload cost that drag type re-entry vehicles appear most probable for the foreseeable future.

The author is a flyer, and not a rocket or missile man. Thus, he may be excused some lack of familiarity with rocket powerplants and associated gear. Technical descriptions tend to be oversimplified at times. The writing style is good, sparkling with conversation, but often overdramatic and exaggerated (e.g. on page 121), "LOX is a strange, deadly substance . . . ."

All in all, this is a book for the winged flight enthusiast—the story of an airplane carried to the extreme in speed and altitude, right out of the normal and proper operating environment of the vehicle.

Fred C. Durant III
Avco RAD

The Exploration of Space, edited by Robert Jastrow, The Macmillan Co., New York, 160 pp.. $5.50.

Thirteen of the country's top scientists engaged in astronomy and space research met in Washington, D.C., in the spring of 1959 to hold a symposium on research aims, findings, and measurement techniques. This rather thin but meaty book is a compilation of the papers presented and discussed at that meeting held under the auspices of NASA, NAS, and the American Physical Society.

In his introductory remarks, editor Jastrow states that "space physics had come into existence" in 1957, a statement which would raise quite a few eyebrows. Certainly the sounding rocket experiments conducted by the military services since the war laid the groundwork for today's satellite payloads. The V-2 program at White Sands in 1946–47 and subsequent work by the informally organized Rocket Research Panel cannot be ignored.

The aim of the symposium was threefold: To awaken and attract interest in space physics within the "scientific community," to present an estimate of current and future U.S. launching capabilities and to acquaint the experimentalist with "existing instrumentation . . . and to challenge his ingenuity in the construction of new apparatus." The names of the authors form an impressive array since they are well known to space buffs who have followed trade press and publications of professional societies over the past few years.

The leadoff paper by Fred L. Whipple surveys the results of meteorite research from terrestrial and satellite bases. Professor Whipple describes

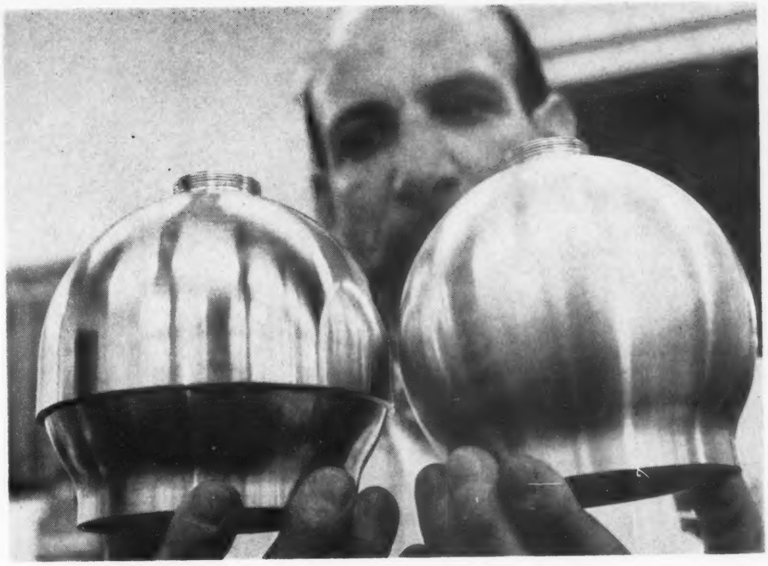
future possibilities for meteorite instrumentation in space vehicles but stresses that the majority of data currently required can be obtained from the earth. Thomas Gold (Cornell Univ.) and Eugene Parker (Univ. of Chicago) discuss the still controversial question of transport mechanisms of charged particles from the sun to the earth. Gold and Parker have different theories and they eloquently argue and defend their views. This controversy is an intriguing insight into the pattern of thought and reasoning of scientists. This reviewer found the presentations exciting as a vignette of the expanding frontier of scientific research.

James Van Allen (State Univ. of Iowa) discusses geomagnetically trapped corpuscular radiation with respect to data obtained from instrumentation contained in Explorer I and III satellites and previous current and postulated theory. Closely related, N. C. Christofilos (Univ. of California) describes his famous and significant Argus experiment in which three small fission bombs were detonated beyond the atmosphere from the south Atlantic Ocean.

Homer Newell (NASA) reviews the panorama of current and planned space launching vehicles, development schedules, and payload launching capabilities. Included are a number of excellent, simplified diagrams and tables that were prepared originally for Congressional budget presentations. Gerard P. Kuiper (Yerkes and McDonald Observatories) reviews in a clear, concise manner facts and conjectures about the moon and characteristics of its surface and structure. Like Whipple, he makes a plea for more terrestrial observations, pointing out the greater relative return of data compared with space observations. Harold C. Urey (Univ. of California) presents a review of characteristics and theories of the origin of iron, iron-nickel, stony and stony iron meteorites. Gerard de Vaucouleurs (Harvard College Observatory) reviews the astronomical, astrophysical, and geophysical data available on Mars and Venus. These kinds of data he categorizes as "rather complete," "incomplete," and "fragmentary," respectively.

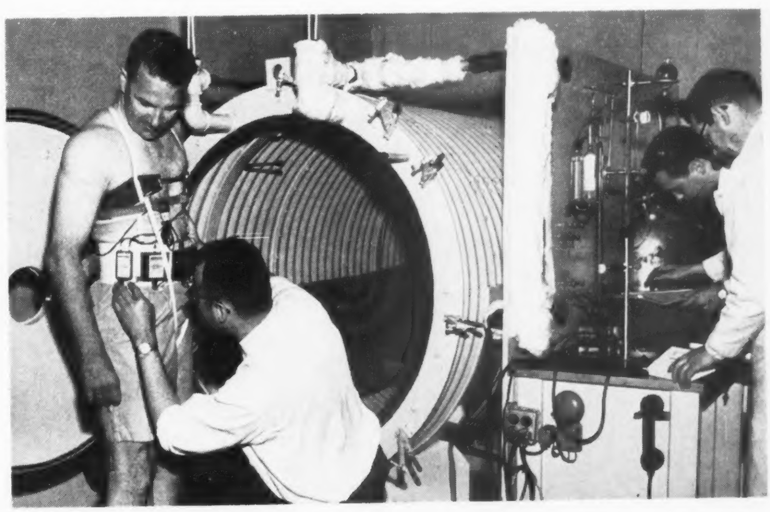
Herbert Friedman (Naval Research Laboratory) and Leo Goldberg (Univ. of Michigan) present a fascinating pair of papers on possible astronomical experiments from satellites and space probes. These papers give a clear view of the fascination that space research holds for the imaginative astronomer and an educated briefing for the uninitiated. Robert Jastrow con-

(CONTINUED ON PAGE 36)



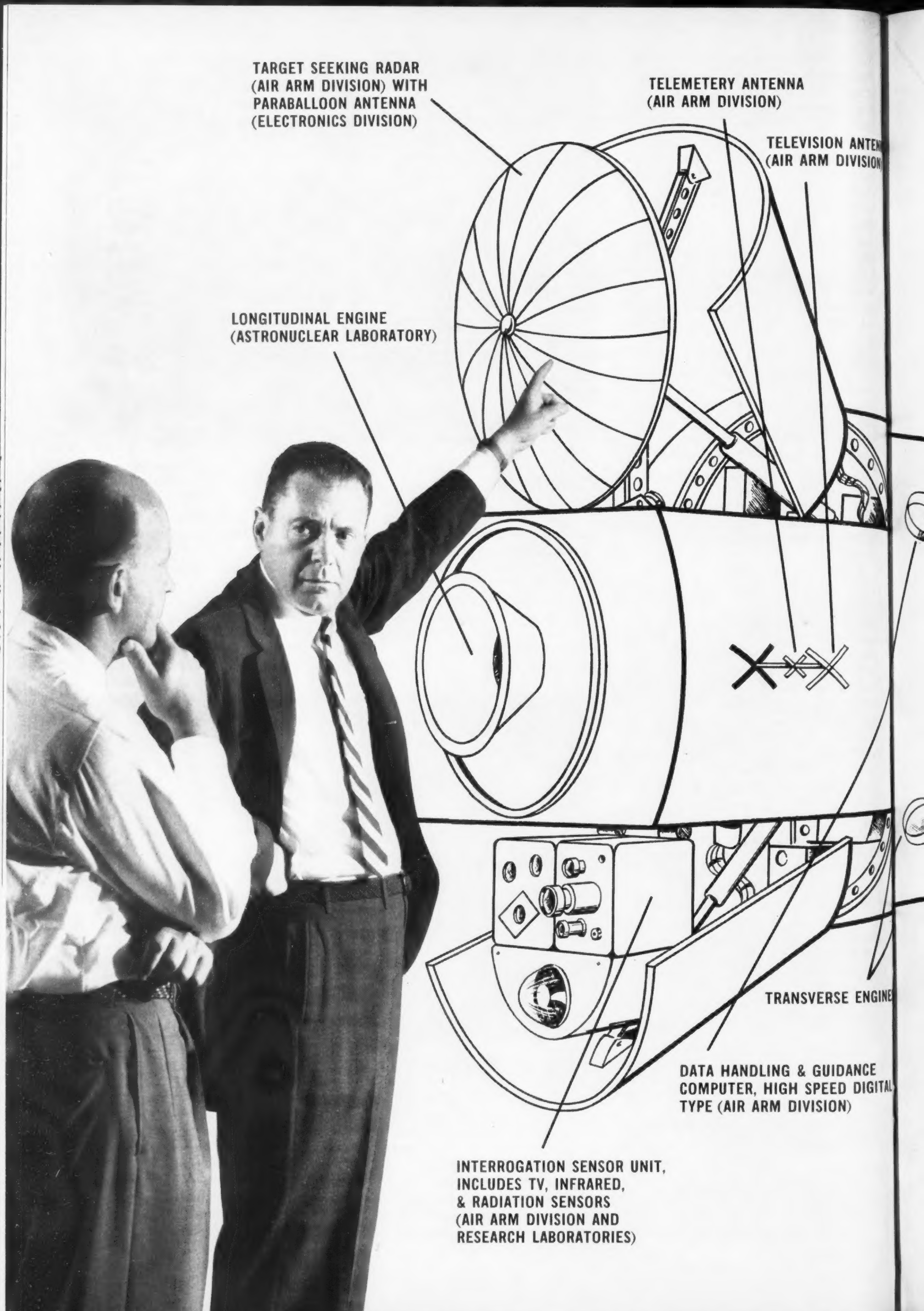
Re-enterers

An engineer holds examples of the spherical rocket motor made by Aerolab Development Co. for the last stage of NASA's six-stage re-entry study vehicle. (See the August 1959 *Astronautics*, page 29.)



Living on Oxygen from Algae

Romny H. Lowry, a medical doctor and manager of the Boeing Space Medicine Section, prepares to step into the chamber and exist for several hours on oxygen supplied by green algae. The test was the first of its kind. Dr. Lowry wears Boeing-developed miniaturized instruments for measuring and recording body functions such as heartbeat, respiration rate, and temperature. Boeing's extensive work in this area has as its goal a closed ecological system and associated equipment for manned spaceflight.



TARGET SEEKING RADAR (AIR ARM DIVISION) WITH PARABALLOON ANTENNA (ELECTRONICS DIVISION)
TELEMETERY ANTENNA (AIR ARM DIVISION)
TELEVISION ANTEN (AIR ARM DIVISION)
LONGITUDINAL ENGINE (ASTRONUCLEAR LABORATORY)
TRANSVERSE ENGINE
DATA HANDLING & GUIDANCE COMPUTER, HIGH SPEED DIGITAL TYPE (AIR ARM DIVISION)
INTERROGATION SENSOR UNIT, INCLUDES TV, INFRARED, & RADIATION SENSORS (AIR ARM DIVISION AND RESEARCH LABORATORIES)

Careers in astronautics

By Irving Michelson, *Illinois Institute of Technology*

ENGINEERS with aircraft backgrounds, looking toward space programs as they move toward second-generation development, are showing interest in the Douglas Missileer program. While this may well be the last carrier airplane, the Missileer launching platform for the Eagle air-to-air missile with nuclear warhead will place heavy demands on manpower for some years to come. Other contracts for the same weapon system: Bendix-Pacific, for Eagle production; Aerojet, solid rockets for the missile; and Pratt & Whitney, turbofan jet engine for the aircraft. All these companies can be expected to call on the best available engineering talent for their portions of the program.

° ° °

Testimony by Bell Telephone experts before the FCC has focused attention on another aspect of the Space Age—a satellites transoceanic telephone communications system. Bell expects each satellite to handle up to 600 calls simultaneously and, with a network of 50 satellites, each costing $1 million, expects the annual rate of transoceanic calls to reach 100,000,000 by 1980. They noted that either a substantial band of frequencies or some significant advances in communications technology would be required. AT&T spokesmen added that several years of basic research in communications technique and equipment will be necessary before a broad commercial system could be established. Sounds like a challenging job for communications specialists.

° ° °

Formation by the Air Force of Aerospace Corp. has touched off another quest for top scientific and engineering talent to manage AF ballistic missile programs. Assigned responsibility for a variety of major programs, including successors to Minuteman and Nike-Zeus, as well as AF counterparts to Polaris and Pershing, the new company will offer opportunities to systems analysts, operations researchers, advance design specialists, programming theorists, and many others.

° ° °

According to our friends in the lunar studies game, seeking a back-up plan to guard against delays in manned expeditions, it appears altogether reasonable to consider the scientific value of securing lunar surface samples by means of core-drilling equipment carried to the moon on an unmanned rocket. Whether or not the sample is actually returned to earth, it could be made to furnish data, perhaps far more readily than bv dispatching a live observer directly to the exploration site. In this light, it makes good sense to ask just how light, rugged and automatic core-drilling equipment can be, and the astroscientists may push for an effort of no mean scale to refine the design of such equipment in the near future. It should prove a real challenge to the mechanical designer.

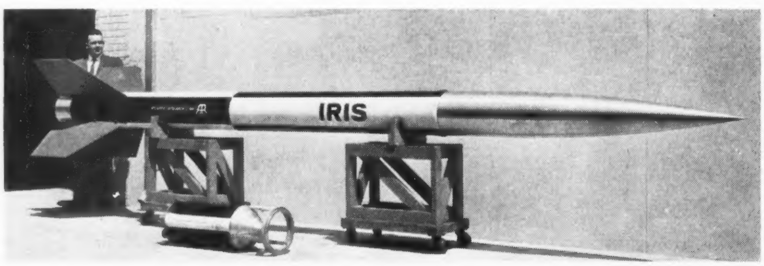
° ° °

The broader question of the need within space programs for an ever-widening range of specialist talents has also been tackled and reported upon by the House Committee on Science and Astronautics in Congress. The Committee's point is illustrated by a listing of no fewer than 49 different categories of professional specialist, all currently engaged in space programs for a single contractor to NASA and DOD. Although the list is dominated by engineers and scientists, it also includes sociologists, medical men, and sundry others. One of the less expected listings is that of oceanographer, but very little reflection is required to think of important space-related problems that must be referred to these experts, quite aside from the obvious problems of recovery following re-entry. It may also be noted that the Committee felt that studies in oceanography have lagged seriously, hampered by inadequate funds and ill-defined direction within government. Greatly enlarged programs are being urged which are expected to require at least a decade of intensive research.

° ° °

The same Committee also addressed itself to questions of academic curricula in astronautics, to meet the needs of programs now under way and in future, and concluded that increased study opportunities will undoubtedly result in direct proportion to growth of astronautical activity. Further questions, as to the specific form of the expanded university activity and the division between intensification of traditional areas and the introduction of essentially new programs, have been avoided. Our own opinion is that augmented efforts in the classical areas will yield the biggest payoffs in the space sciences, while the technologies have the most to gain by revision of standard curriculum patterns.

For specific career opportunities this month, see pages 1, 2, 5, 15, 22, 35, 44, 49, 53, 59, 67.



Iris Soars to 140 Miles

Iris, the largest of Atlantic Research's family of solid-propellant sounding rockets (others, Arcas and Arcon), was launched by NASA for the first time recently from Wallops Island. Shown above, the 20-ft rocket packed a 150-lb payload to altitude of 140 miles. The seven-motor cluster in the foreground added to initial boosting thrust. The main motor burned for about 62 sec and brought the rocket to a velocity of 6774 fps at burnout.

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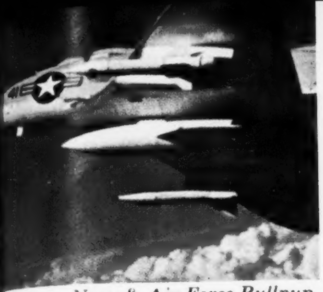
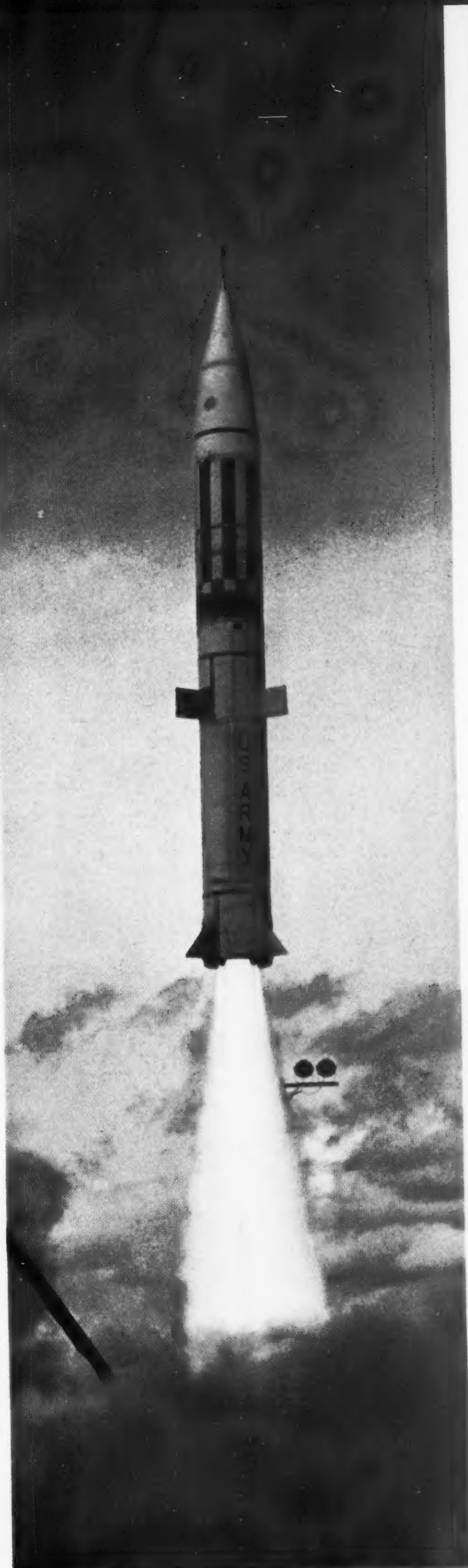


Navy & Air Force Bullpup

Air Force Mace

Army Lacrosse

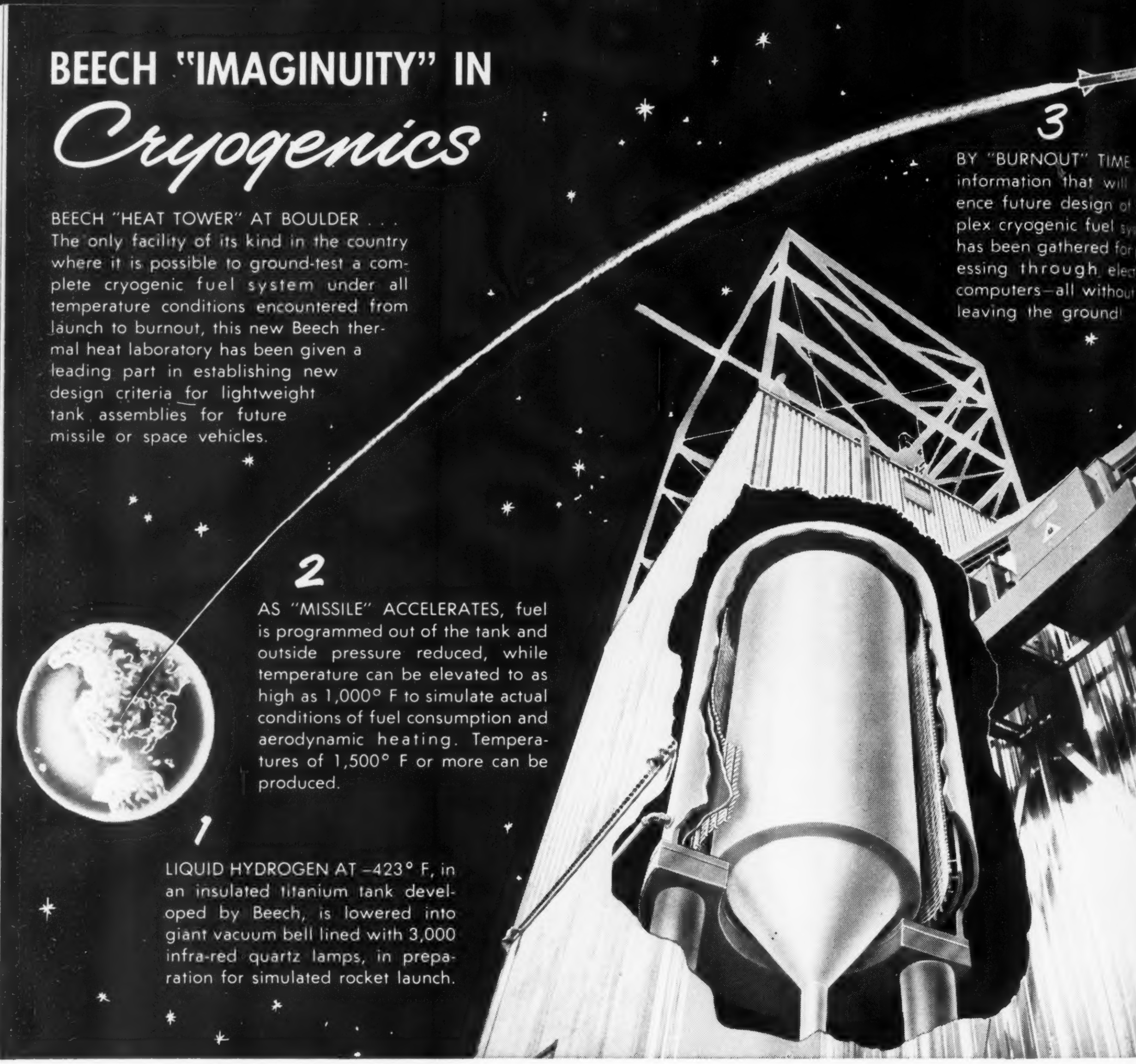


Army Pershing

Air Force Titan

Five major U.S. missiles developed and built by Martin

MARTIN



Beech "space flights" at Boulder, Colorado . . .

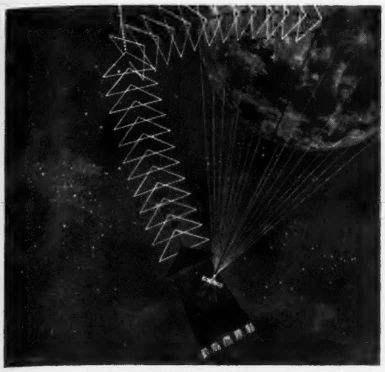
Pioneering in testing of space vehicle components ...including liquid hydrogen fuel tankage systems

Big things are happening at Boulder. Here, near the Bureau of Standards cryogenic engineering laboratory, Beech has assembled a highly competent team of scientists, engineers and technicians, chosen for a combination of skills, experience and interests. Working with the most modern equipment (much of it Beech-developed), this team is performing vital roles in perfecting advanced propulsion systems and components. Beech qualifications for future assignments include more than 6 years experience in liquid hydrogen propellants and liquid hydrogen storage; research, development and fabrication of titanium tankage systems; and environmental testing of a wide range of missile components and systems to qualification.

Beech Aerospace Division projects include R&D on manned aircraft; missile target and reconnaissance systems; complete missile systems; electronic guidance systems; programs pertaining to liquid hydrogen propellants and cryogenic tankage systems; environmental testing of missile systems and components; and GSE. May we help you? Write, wire, or phone Contract Administrator, Beech Aircraft Corp., Wichita 1, Kansas—or nearest Area Office.

Beech Aerospace Division

BEECH AIRCRAFT CORPORATION • WICHITA 1, KANSAS.



COVER: *A depiction of optical-inertial guidance about to take a space vehicle from a hyperbolic Earth-Moon trajectory to a precise lunar landing—one of several challenging space missions for the new decade (see page 24). The colorful cover is the work of Autonetics artist Ken Hodges. (Full-color ASTRO cover plaques are available from ARS Headquarters at $2.00 each.)*

Astronautics

SEPTEMBER 1960

"Publish and Perish"

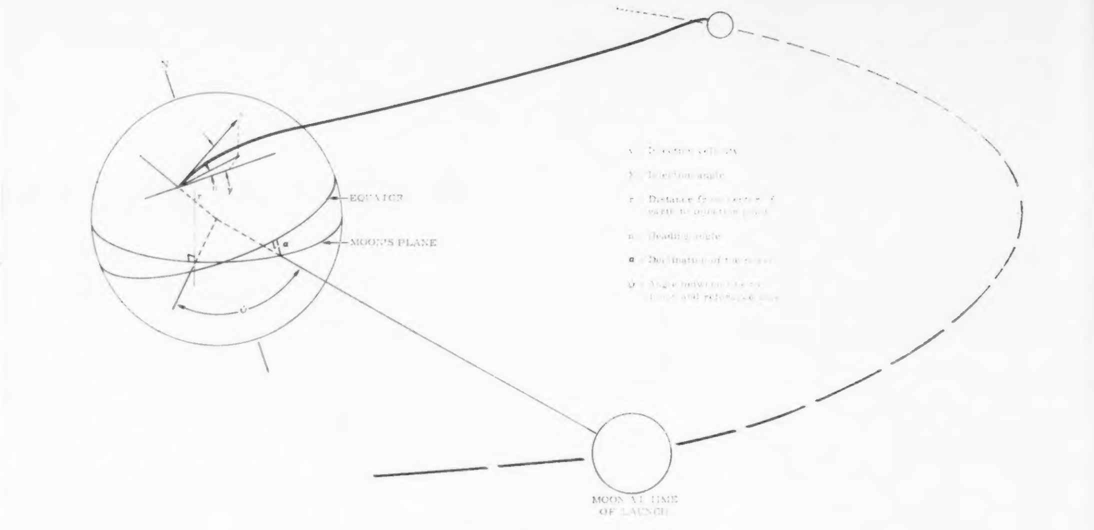
Professor Kenneth Eble of Utah, writing in the Columbia University *Forum*, has used the words "publish and perish" to describe the plight of liberal arts scholars and editors who "recognize the dubious quality of much that is printed, but seem committed to the belief that too many journals are better than too few." He points out that American literary publications have increased fourfold in the last decade, and attributes this to the principle that "professors must publish." Further, "Manuscripts pile up on editors' desks. They accumulate in scholars' desk drawers. Their eventual publication does not so much reveal the refinement possible to the human mind as it discloses the brute osmotic pressure which manuscripts generate going from journal to journal until they are finally absorbed at one place or another."

Eble asks, "What can be done? How can we get fewer publications, and more publications that are *good?* Would we get an enlightened Federal Communications Commission to watch over publishing? If we did, its first action would be to establish a journal. Men will write. Praise their work and they will send it to a magazine. Sneer at it and they will start one of their own. Hang the promotions of college teachers on how much they publish and a pernicious inclination becomes a malignant necessity."

He continues, "Efforts to keep up with multiplying journals are futile. Bibliographies lead to more bibliographies. Abstracts spawn *journals* of abstracts. Article-digest magazines put articles which the general reader hasn't had time to read into a periodical he won't get around to reading. The most that can be hoped for are 'Abstracts of the Best' or perhaps 'Best of the Abstracts.' "

It seems that what is true for the humanities goes double for the sciences. Not only must professors publish for prestige and pay, but corporations must compete for the defense dollar, with printed words as weapons. Perhaps it is time to attack the problem at its source, and give a Pulitzer Prize to the journal which has most impressively refrained from publishing on subjects not worth writing about. The field is wide open to the man or the group who can systematize the confusion, and who can reduce this Tower of Babel to a harmonious chorus.

Howard S. Seifert
President, American Rocket Society



Earth-Moon Transit Trajectory

Lunar guidance

Lunar missions, such as a soft landing, and interplanetary flights calling for accurate terminal guidance will profit from the broad capabilities of the optical-inertial system

By Hildrey I. Bement

AUTONETICS, A DIV. OF NORTH AMERICAN AVIATION INC., DOWNEY, CALIF.

Hildrey I. Bement is a research specialist responsible for planning, directing, and executing complex theoretical analyses of guidance systems at Autonetics. He received B.A. and M.A. degrees in mathematics in 1951 and 1955, respectively, and did two years of study toward a doctorate in mathematics and physics at Louisiana State Univ. Experience prior to his present position included nearly 10 years in operations research, armament-systems analysis, data-system applications, analysis of guidance systems, and college teaching.

THE OPTIMUM lunar guidance system is a complex function of many mission and vehicle parameters—payload; choice of manned or unmanned vehicle; accuracy; propulsion system; launching position and time; choice of hard, soft, or semihard landing; lunar longitude and latitude of expected impact; and knowledge of the surface of the moon—and from these parameters can be determined the extent of guidance required for a particular mission. High-accuracy impact points—on the order of 1000-ft probable circular error (CEP)—will require initial, midcourse, and terminal guidance. Impact points accurate to 10 or 15 miles can be accomplished without the terminal phase; and simply impacting the moon need call for no more than initial guidance.

For the short distance of lunar travel, several possibilities for guidance present themselves. The chief competitors are radio and optical-inertial systems. Radio-inertial, pure inertial, and optical systems are other possibilities. The choice of a guidance system for a particular mission will depend on weight, reliability, accuracy, cost, growth possibilities, and the length of time required for its development and production.

The existing literature does not give the optical-inertial system the attention it deserves. Furthermore, the capabilities of this system are often underestimated in the literature. For this reason, our

discussion will put some emphasis on optical-inertial guidance, and suggest appropriate applications for various missions.

A radio system for initial and midcourse guidance would be lighter than an optical-inertial one, since part of its equipment can be on earth. An optical-inertial system, however, is in some respects particularly attractive for terminal guidance. For example, an optical-inertial system gives increasing accuracy with approach to the target, whereas radio guidance does not. Also, an optical-inertial system is not inherently range-limited. Comparative costs of the two systems depend largely on respective states of development and the modifications necessary to existing components.

The significant lunar missions, both scientific and military, for the near future are lunar impact, orbiting the moon, and soft landing on the moon. These missions are very general and consequently do not help much in defining the required guidance-system performance. However, when terminal accuracy is specified for these missions, then performance requirements can be determined.

Lunar Impact

Consider the mission of simply impacting the moon at any point, with perhaps the purpose of photographing its surface before impact. For this mission the inertial- or radio-guidance systems presently employed in ballistic missiles are accurate enough. This could be a borderline case, however, if the cutoff velocity were near the minimum required to get to the moon; then the velocity error would be extremely critical, as can be inferred from the graph shown below left.

What is really desirable when only impact is required? To minimize weight, cost, and complexity, it is very desirable to have a slightly greater velocity at cutoff than the required minimum and to have only initial guidance. For example, at an altitude of 350 statute miles the minimum required velocity is a little less than 34,800 fps. At this value no error in velocity magnitude is allowable. If this is increased to 34,900 fps, there is no longer any problem in attaining the required cutoff accuracy. Further, as the graph below left indicates, there is no problem in attaining the required angular accuracy. It should be fairly simple, then, to hit the moon with only initial guidance if the cutoff velocity at an altitude of 350 statute miles is 34,900 fps or greater; for, in this case, the required velocity accuracy is on the order of 50 fps, and the required angular accuracy is about one-half minute. (The graph below right shows impact sensitivity to variation in velocity.)

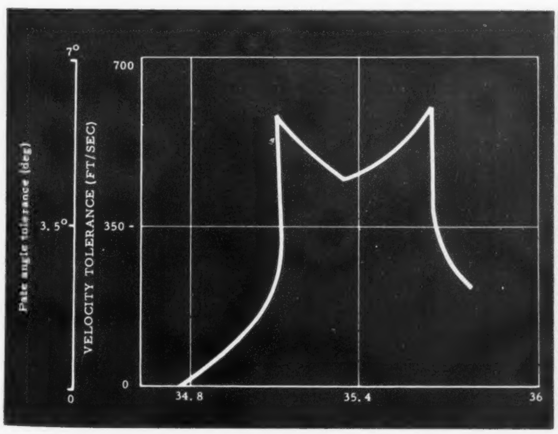
Soft Landing

Both midcourse and terminal guidance will be needed to land on the moon with a position accuracy of 1000 ft or less. For semihard or soft unmanned landings, multiple missions may necessitate accuracies of this order. Manned vehicle landings will have to be very accurate because of the variability and ruggedness of the terrain.

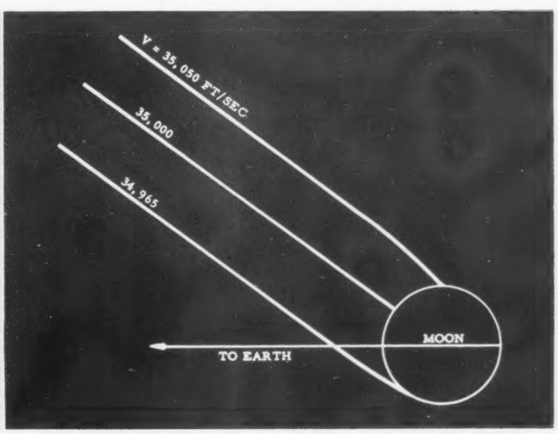
Manned lunar landings by the U. S. are at present planned for the early 1970's with the use of the Nova vehicle. Soft landings with instrument payloads are planned for the latter part of the 1960's using the Saturn vehicle. Earlier soft landings will be made, but with reduced payloads, as a result of the Centaur project. The Centaur project aims at a soft lunar landing in 1962.

Consider the mission of soft-landing an instrument package on the moon with (CONTINUED ON PAGE 77)

Total Velocity and Path-Angle Tolerance to Hit the Moon



Effect of Varying Velocity on Impact Location



Cyborgs and space

Altering man's bodily functions to meet the requirements of extraterrestrial environments would be more logical than providing an earthly environment for him in space . . . Artifact-organism systems which would extend man's unconscious, self-regulatory controls are one possibility

By Manfred E. Clynes and Nathan S. Kline

ROCKLAND STATE HOSPITAL, ORANGEBURG, N. Y.

Clynes Kline

Manfred E. Clynes has since 1956 been chief research scientist at Rockland State, in charge of the Dynamic Simulation Lab. A graduate of the Univ. of Melbourne, Australia, and holder of an M.S. from Juilliard School, he has for the past 10 years been engaged in the design and development of physiological instrumentation and apparatus, ultrasonic transducers, and electronic data-processing systems.

Nathan S. Kline has been director of research at Rockland State since 1952 and an assistant professor of clinical psychiatry at the Columbia Univ. College of Physicians and Surgeons since 1957. Author of more than 100 papers, Dr. Kline holds a New York Newspaper Guild Page One Award in science, the Adolf Meyer Award of the Assn. for Improvement of Mental Health, and the Albert Lasker Award of the American Public Health Assn.

This article is based on a paper presented under the title of "Drugs, Space and Cybernetics" at the Psychophysiological Aspects of Space Flight Symposium sponsored by the AF School of Aviation Medicine in San Antonio, Tex., in May. The complete paper will appear in the Symposium proceedings, to be published by Columbia Univ. Press.

SPACE travel challenges mankind not only technologically but also spiritually, in that it invites man to take an active part in his own biological evolution. Scientific advances of the future may thus be utilized to permit man's existence in environments which differ radically from those provided by nature as we know it.

The task of adapting man's body to any environment he may choose will be made easier by increased knowledge of homeostatic functioning, the cybernetic aspects of which are just beginning to be understood and investigated. In the past evolution brought about the altering of bodily functions to suit different environments. Starting as of now, it will be possible to achieve this to some degree *without alteration of heredity* by suitable biochemical, physiological, and electronic modifications of man's existing modus vivendi.

Homeostatic mechanisms found in organisms are designed to provide stable operation in the particular environment of the organism. Examples of three successful alternate solutions provided by biological mechanisms to the body-environment problem with regard to operating temperature are man, hibernating animals, and poikilothermic fish (organisms with blood that take on the temperature of the environment).

Various biological solutions have also been developed for another problem—respiration. Mammals, fish, insects, and plants each have a different solution with inherent limitations but eminently suitable *for their field of operation.* Should an organism desire to live outside this field, an apparently "insurmountable" problem exists.

However, is the problem really insurmountable? If a fish wished to live on land, it could not readily do so. If, however, a particularly intelligent and resourceful fish could be found, who had studied a good deal of biochemistry and physiology, was a master engineer and cyberneticist, and had excellent lab facilities available to him, this fish could conceivably have the ability to design an instrument which would allow him to live on land and breathe air quite readily.

In the same manner, it is becoming apparent that we will in the not too distant future have sufficient knowledge to design instru-

mental control systems which will make it possible for our bodies to do things which are no less difficult.

The environment with which man is now concerned is that of space. Biologically, what are the changes necessary to allow man to live adequately in the space environment? Artificial atmospheres encapsulated in some sort of enclosure constitute only temporizing, and dangerous temporizing at that, since we place ourselves in the same position as a fish taking a small quantity of water along with him to live on land. The bubble all too easily bursts.

The biological problems which exist in space travel are many and varied. Long-term space voyages, involving flights not of days, months or years, but possibly of several thousand years, will eventually be hard realities, and resultant physiological and psychological conditions must be considered.

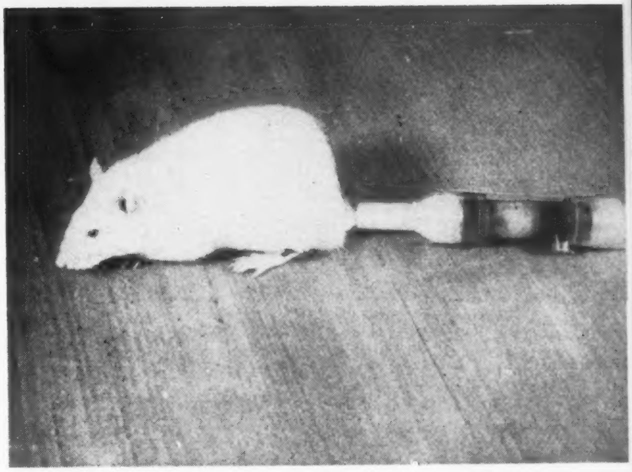
These are reviewed below. In some cases, we have proposed solutions which probably could be devised with presently available knowledge and techniques. Other solutions are projections into the future which by their very nature must resemble science fiction. To illustrate, there may be much more efficient ways of carrying out the functions of the respiratory system than by breathing, which becomes cumbersome in space. One proposed solution for the not too distant future is relatively simple: Don't breathe!

If man attempts partial adaptation to space conditions, instead of insisting on carrying his whole environment along with him, a number of new possibilities appear. One is then led to think about the incorporation of integral exogenous devices to bring about the biological changes which might be necessary in man's homeostatic mechanisms to allow him to live in space *qua natura*.

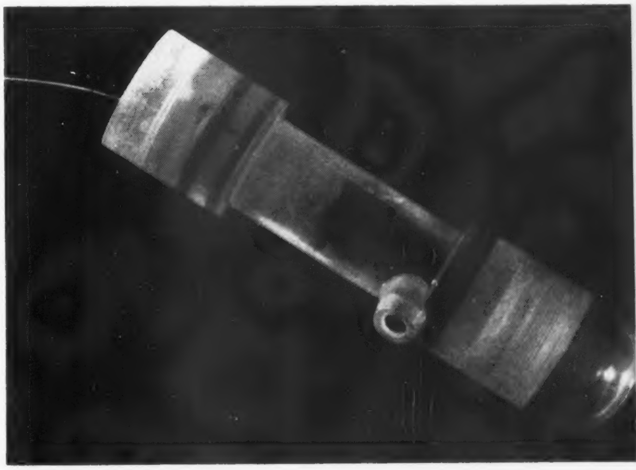
The autonomic nervous system and endocrine glands cooperate in man to maintain the multiple balances required for his existence. They do this without conscious control, although they are amenable to such influence. Necessary readjustments of these automatic responses under extraterrestrial conditions require the aid of control theory, as well as extensive physiological knowledge.

Cyborg—Frees Man to Explore

What are some of the devices necessary for creating self-regulating man-machine systems? This self-regulation must function without the benefit of consciousness in order to cooperate with the body's own autonomous homeostatic controls. For the exogenously extended organizational complex functioning as an integrated homeostatic system unconsciously, we propose the term "Cyborg." The Cyborg deliberately incorporates exogenous components extending the self-regulatory control function of the organism in order to adapt it to new environments.



One of the first Cyborgs, this 220-gm rat has under its skin the Rose osmotic pump (shown in close-up below), designed to permit continuous injections of chemicals at a slow, controlled rate into an organism without any attention on the part of the organism.



If man in space, in addition to flying his vehicle, must continuously be checking on things and making adjustments merely in order to keep himself alive, he becomes a slave to the machine. The purpose of the Cyborg, as well as his own homeostatic systems, is to provide an organizational system in which such robot-like problems are taken care of automatically and unconsciously, leaving man free to explore, to create, to think, and to feel.

One device helpful to consideration of the construction of Cyborgs, which is already available, is the ingenious osmotic pressure pump capsule developed by S. Rose for (CONTINUED ON PAGE 74)

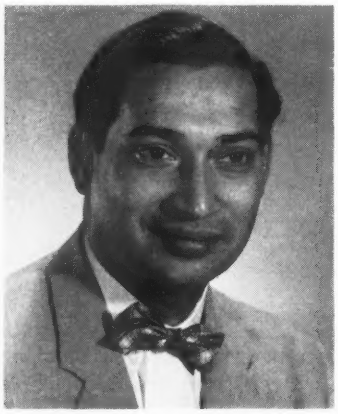

The experimental rocket engine with an E-D nozzle fires at Rocketdyne's Santa Susana static-testing facilities; left, at ignition and, right, during steady-state operation.

The E-D nozzle

Tests confirm that its novel design brings both reduced size and weight and improved thrust performance at low altitudes

By G. V. R. Rao

ROCKETDYNE, A DIV. OF NORTH AMERICAN AVIATION INC., CANOGA PARK, CALIF.



G. V. R. Rao has been a rocket-design specialist with Rocketdyne since 1958. Born in Rajahmundry, India, he early attended the Madras Engineering College, and later, under the sponsorship of the Indian government, New York Univ., where he received a Ph.D. in engineering science in 1949. Before joining Rocketdyne, Dr. Rao was an assistant professor at the Indian Institute of Science in Bangalore from 1951 to 1952, an engineer with GE's Aircraft Gas Turbine Div. from 1952 to 1955, and a research scientist with Marquardt Aircraft from 1955, when he became an American citizen, to 1958. Dr. Rao has made numerous contributions to the literature.

ROCKET thrust depends primarily upon the momentum imparted to the exhaust gases in the nozzle. It has been a customary practice to use convergent-divergent (bell) nozzles with the minimum cross section located perpendicular to the nozzle axis. The bell-nozzle length can be considerably reduced, however, without undue loss in thrust by contouring its walls. One sketch at the bottom of the opposite page shows a conventional bell nozzle.

Since thrust depends only upon the flow conditions at nozzle exit, one may examine other types of nozzles where the throat flow is not necessarily parallel to the axis, but the exit flow is similar to that of a conventional nozzle. One such type is the so-called plug, or spike, nozzle. Here the combustion chamber is located as an annulus at the maximum diameter, as shown by the middle sketch. The flow direction at the throat region is quite different from axial, and the plug contour will be so designed to turn the expanding gases into a nearly axial direction to provide thrust comparable to that of a bell nozzle.

On the other hand, the annular throat can be located at a short radial distance from the nozzle axis, with the flow direction outward, as shown in the third sketch. In this case the nozzle wall, in the shape of a shroud, will turn the expanding gases into a nearly axial direction, resulting in exit flow and thrust performance comparable to that of a conventional bell nozzle. It is known from the properties of expansion waves, which determine the flow fields, that both of the latter two types of nozzles are considerably shorter than bell nozzles. Locating the throat annulus not far from the axis results in a great advantage over a plug-type nozzle in the size of the combustion chamber, its structural design, and its heat transfer to the chamber walls. This new nozzle with a small central plug has been dubbed an E-D (expansion-deflection) type, since the "expansion"

A technician inspects the E-D nozzle used in cold-air blow-down tests (see page 50).

occurs around a centrally located plug and the expanding gases are "deflected" by the nozzle wall into a nearly axial direction.

To evaluate the thrust performance of a rocket nozzle at various altitudes, one has to examine how the ambient pressure affects the flow through the nozzle. In a conventional bell nozzle, the exhaust gases expand from the chamber pressure to pressures well below the ambient before flow separation from the nozzle wall occurs. This "over-expansion" results in thrust loss at low altitudes. In the case of the E-D nozzle, the pressure, p_b, that occurs on the rear face of the plug plays an important role. For a typical low-altitude condition, the essential nature of the flow of the exhaust gases is schematically shown by the sketch on page 50. The expansion of exhaust gases, about the central plug shoulder, continues unaffected until pressure, p_b, is reached at the point C_1. Let C_1P_1 be the last Mach wave in this unaffected portion of the flow. Downstream of this Mach wave, C_1P_1, the exhaust gases are confined between the contoured nozzle wall and the free-stream surface prescribed by pressure p_b in the region behind the plug. Due to the nozzle wall curvature, the exhaust gases downstream of C_1P_1 encounter compressive turning and the wall pressure rises. The compressive turning downstream of P_1 continues along the wall until reflected waves, such as Q_1R_1, reach the nozzle walls. From this point on, the nozzle wall pressures would again drop. If the pressure, p_b, behind the plug were sufficiently low, the expansion of the exhaust gases would continue unaffected up to the end of the nozzle, and the resulting wall pressures would be as indicated by the dotted line in the sketch. The behavior of wall pressures here is very similar to what one obtains on a spike (external-plug) nozzle operating at below-design pressure ratios, as discussed, for instance, by Beale and Pavolny in 1957.

The flow patterns anticipated in an E-D nozzle operating at various altitudes are shown by the sketches on page 50. At very low pressure ratios, corresponding to low-altitude operating conditions, the entire flow is close to the nozzle wall, with a void in the middle. The pressure in this region is slightly lower than the ambient pressure. As the ambient pressure is lowered, corresponding to increased altitudes, the flow comes closer to the nozzle axis behind the plug. At very high altitudes the flow converges behind the plug. Since the flow at the closure point must be axial, there would occur a shock wave compatible with the flow conditions. The size of the plug being small, the sub-ambient pressures on it do not materially effect the thrust performance of the nozzle.

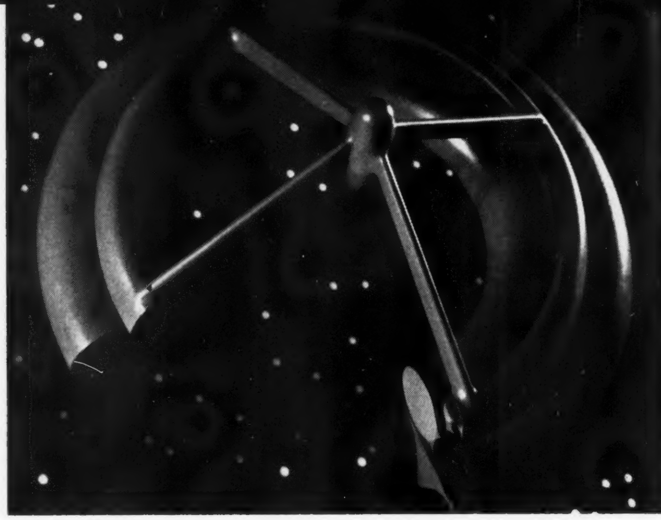
The thrust coefficient of a rocket nozzle can be nondimensionalized by referring to the ideal thrust coefficient for the altitude. Assuming a chamber pressure of 500 psia, the graph on page 50 shows the thrust efficiency versus altitude curve for an E-D nozzle of area ratio 25:1. For the sake of comparison, the performances of conventional bell nozzles of area ratios 8:1 and 25:1 are also shown on this graph. The compressive turning on the nozzle wall, which is also evident in the plug-type nozzle, is responsible for the improved performance at low altitudes. Hence, the thrust performance versus altitude shown here for the E-D nozzle is quite similar to the performance of the plug-type nozzle, as described by Berman in the April *Astronautics*.

Cold-Air Blow-Down Tests

To obtain experimental verification regarding the operating principles of E-D nozzles, cold-air blow-down tests and rocket-firing tests were conducted.

For the cold-air blow-down tests, a nozzle contour of the E-D type was designed using $\gamma = 1.4$. The nozzle had an area (CONTINUED ON PAGE 50)

Types of Nozzles



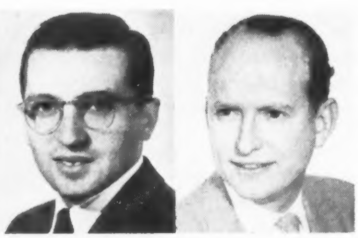
A double toroidal plug-nozzle configuration of a very high thrust level unit in illustrative form.

Plug-nozzle flexibility

This rocket-engine concept encompasses many different configurations, and allows the space-vehicle planner great latitude and flexibility in optimizing his design

By Kurt Berman and Bruce Neuffer

GENERAL ELECTRIC CO., CINCINNATI, OHIO



Berman Neuffer

Kurt Berman, manager of liquid-propellant rocket engines for GE's Flight Propulsion Laboratory Dept. at Malta Test Station, N.Y., received his B.S. in chemistry at Western Reserve Univ. in 1945 and his Ph.D. in applied physics in 1950 at Harvard. An ARS Fellow, Dr. Berman has devoted the past 12 years with GE to work in such areas as rocket-propulsion instability problems, development of new propellants and propellant combinations, and small-particle and encapsulation development. He is an adjunct professor of aeronautical engineering at Rensselaer Poly School of Engineering.

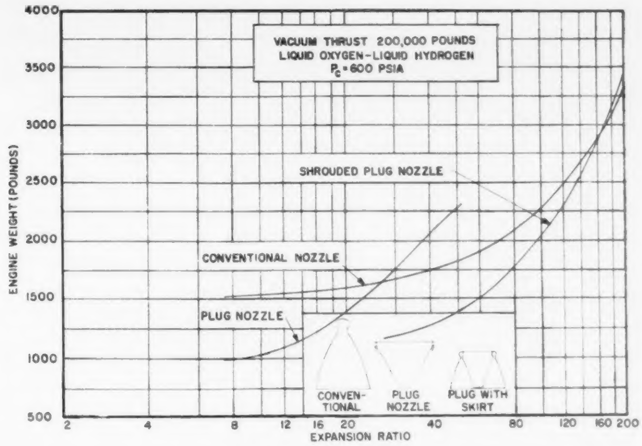
Bruce Neuffer, manager of advanced engineering for GE's FPLD Rocket Engine Section at Malta, received his B.S. in Mechanical Engineering at the Univ. of New Mexico in 1948, when he joined GE and was assigned to Project Hermes. Later he was given responsibility for the entire propulsion system of that pressurized feed-test vehicle. Along with experience in nuclear powerplant systems, he has made engine system and application studies under the preliminary analysis of the GE X-405 rocket engine and subsequent liquid engine projects.

THE PLUG-nozzle engine concept presents a radically different philosophy of engine design rather than a mere component improvement or variation. The "plug-nozzle" engine constitutes not just a single configuration but rather a family of rocket-engine designs whose one common denominator is the segmented annular combustor, which was described and discussed in the April 1960 *Astronautics*, page 22. This type of combustor lends itself very naturally to a combination with a central plug-type nozzle to form a rocket engine, and this combination has marked the genesis of the so-called "plug-nozzle" engine.

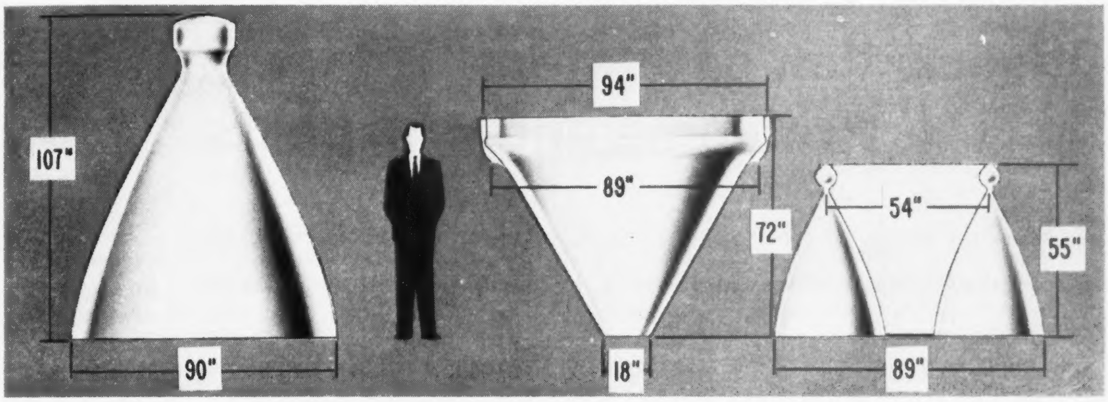
It appears that there has arisen a considerable amount of confusion regarding the nomenclature which is applied to different configurations of the plug-nozzle family. Such names as spike nozzle, inside-out plug nozzle, and external plug have been used on various occasions. For purposes of clarity, we shall define as plug nozzles all rocket nozzles which are used in conjunction with annular combustors or combustion systems terminating in an annular throat. Such propulsion-system configurations will require some sort of central plug. It should be pointed out, however, that the converse is not necessarily true—namely, that a plug nozzle can be used only in conjunction with an annular combustor.

The arbitrary definition of a plug nozzle in terms of the combustor shape appears justified since our objective is not to classify nozzles as distinct and separate components but rather as integral portions of rocket-propulsion systems.

Within the framework of this definition, plug nozzles can be divided into three general aerodynamic types, listed here and shown on the opposite page.



Comparative Weights of Conventional, Unshrouded-Plug, and Shrouded-Plug Engines



1. *All* supersonic expansion occurs external to the combustor (Type A).

2. *Part* of the supersonic expansion occurs external to the combustor (Type B).

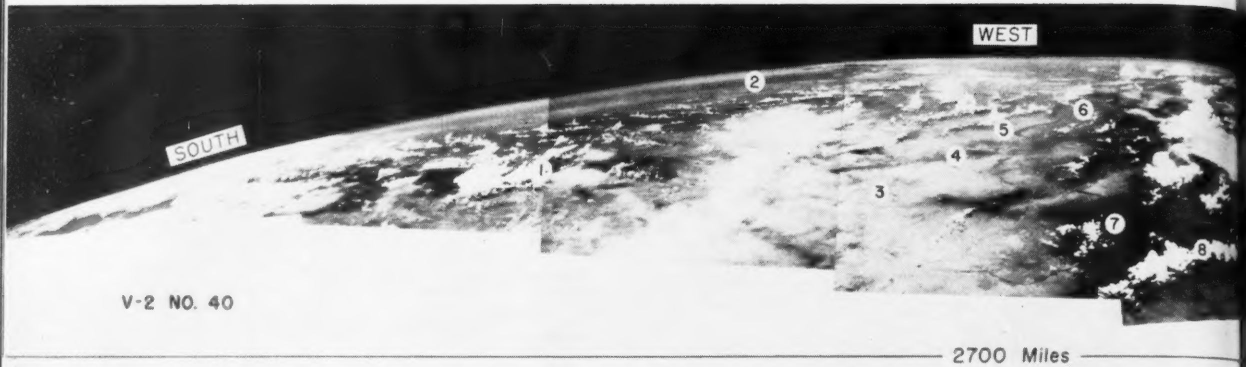
3. *None* of the supersonic expansion occurs external to the combustor (Type C).

Each of these three aerodynamic types can in turn be classified in terms of the general structural configuration in which it is employed. Using the completely external expansion plug (Type A) as an example, we have indicated in the drawings on page 52 two other structural variations from the conventional plug; namely, the double toroidal annular combustor and the single toroidal annular combustor. Similar structural variations can be made from the other two aerodynamic configurations.

Many Forms Possible

Additional classifications based on plug geometry and combustor configuration and orientation with respect to the plug axis can be superimposed on these general categories. For example, the diagram on page 52 shows five possible combustor orientations for a given plug. (CONTINUED ON PAGE 52)

Plug-Nozzle Types Aerodynamically Different



ASTRONAUTICS Report—Part 5

Observation satellites: Problems and prospects

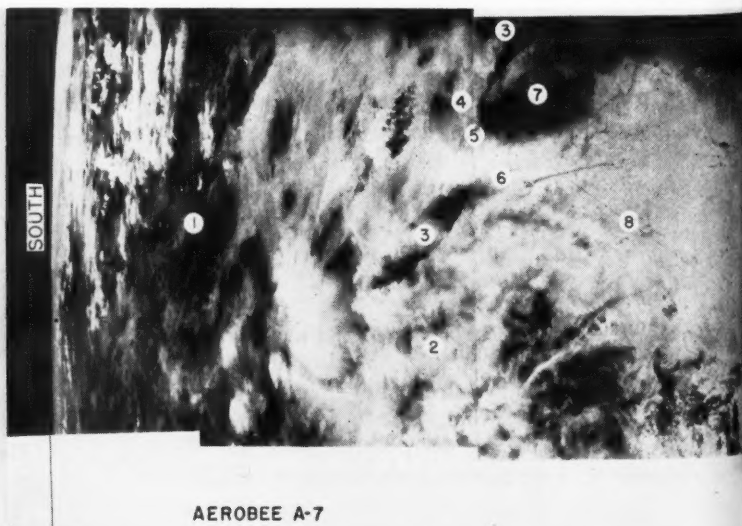
A discussion of the photographic aspects of weather reconnaissance and of the role satellites could play in aerial inspection systems

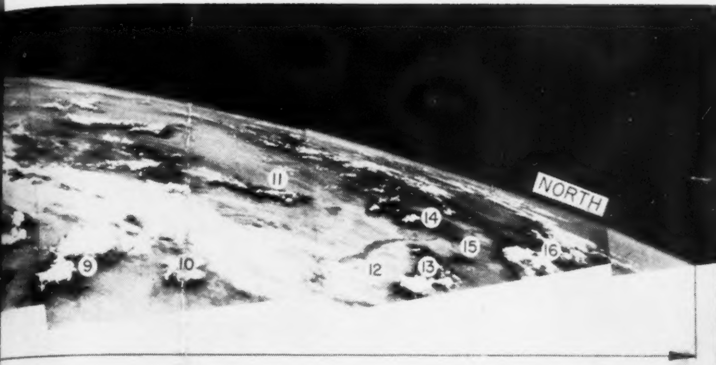
By Amrom H. Katz

THE RAND CORP., SANTA MONICA, CALIF.

THERE are two major areas for work in connection with satellite weather reconnaissance. The first concerns itself naturally with the exploitation and application of the kinds of data which could be collected from satellites. Tiros I has established that cloud pictures can be obtained which are eminently useful for meteorological observation and weather forecasting. Satellites, moreover, could also be used to collect nonphotographic data which might likewise prove useful. Because present techniques for forecasting depend, on the one hand, upon many other kinds of data, and, on the other hand, upon much more limited looks than could be afforded by a weather satellite, it is patent that considerable work must be done in analyzing and per-

Numbers in photo right, taken from Aerobee at 70-mile altitude, identify Mexico (1), Texas (2), the Rio Grande, marked in three different places (3), Ciudad Juarez, Mexico (4), El Paso (5), Southern Pacific Railroad (8), V-2 and Aerobee launch sites at White Sands Proving Ground (11), test site for first atom bomb (20), Albuquerque (21).





Two composite photographs (left and below) taken the same day (July 26, 1948) from two different rocket vehicles, each showing identifiable areas. In photo left, taken from V-2 at 60-mile altitude: Mexico (1), Gulf of California (2), Lordsburg, N. Mex. (3), Gila River (5), San Carlos Reservoir (6), Albuquerque, N. Mex. (12), and Rio Grande River (15), as well as a number of mountain ranges, are all clearly identifiable.

fecting systems for using cloud photographs and the data derivable from them.

The second aspect of this application of satellites concerns the rocketry and satellite art, problems of communication, resolution, bandwidth, transmission, etc. Ostensibly, this collection of problems has very little to do with weather observation as such. A brief discussion of these factors and their relation to other observation technology will clarify this point.

Progress in systems for detailed observation or inspection will inevitably take the direction of higher-resolution systems selectively covering smaller regions on the ground. This type of observation will become more selective with time, and will complement broad-coverage systems. Meteorological observations, on the other hand, can be done at resolutions measured not in feet but perhaps in hundreds of feet. Instead of narrow-angle views of the earth's surface, extremely wide-angle views are required, covering as much area as possible simultaneously. These rather different requirements indicate that the purposes of both fields would be best served by separate satellites. (This does not necessarily rule out the use of high-resolution "sampling," observations for meteorological purposes, or examination of special phenomena.)

The choice of altitudes, flight paths, sensors, stabilization systems, and communication systems might differ between observation satellites (for, say, inspection purposes) and observation satellites (for meteorology). However, data from other observation satellites, while of extreme interest, will be useful in the practicing and learning phase for developing such techniques, specialized ground equipments, and procedures as will enable the full exploitation of meteorological observations.

Satellite Attitude Requirements

It will be remembered that, for recording and observation of small ground detail, satellite altitudes should be as low as possible. Altitudes of 150 or 300 miles are common in such discussions. For the weather observation satellite, it seems clear intuitively that, consonant with the extremely low resolution requirements (CONTINUED ON PAGE 40)

From left, ARS President Howard S. Seifert; Mrs. Robert H. Goddard; Wernher von Braun; Harry Stoddard, Worcester publisher; and Nils T. Ljungquist, a coworker of Dr. Goddard, flank the memorial tablet.

Worcester Telegram and Gazette photos

ARS Goddard Memorial dedicated

Marker and memorial tablet in Auburn, Mass., commemorate site of world's first successful liquid rocket flight on March 16, 1926

By Irwin Hersey

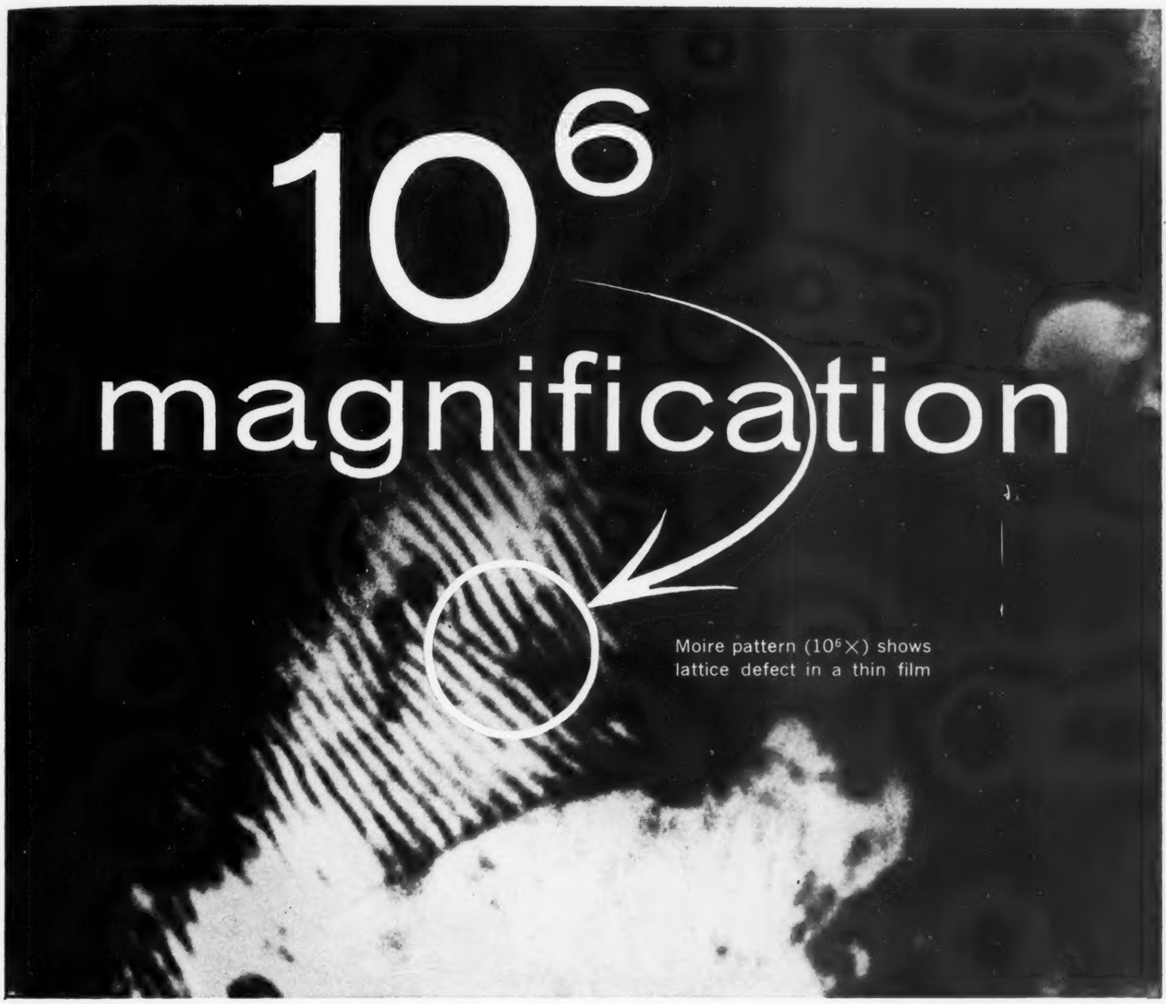
An ARS Memorial to Robert H. Goddard, the father of American rocketry, was dedicated July 13 at the site of the world's first successful liquid rocket flight at Auburn, Mass., in brief but impressive ceremonies held before an audience of 225 people, including some of the nation's top space scientists and engineers.

The Memorial, conceived and sponsored by ARS, consists of a tablet erected adjacent to Pakachoag Road in Auburn, about 1000 ft from the site of the launching, and a marker which indicates the launch site itself. The Memorial was unveiled by Esther C. Goddard, Dr. Goddard's widow, who served as an ex-officio member of the ARS Goddard Memorial Committee and cooperated fully and assisted in all phases of the project. ARS President Howard S. Seifert, Wernher von Braun, and Mrs. Goddard all spoke briefly at the dedication ceremonies.

Dr. Seifert noted that the ARS and Dr. Goddard had long been associated with each other. He pointed out that ARS had reprinted Dr. Goddard's early publications, that Dr. (CONTINUED ON PAGE 51)

Honored guests at the ceremonies. From left, Harry Goett, director of NASA's Goddard Space Flight Center; George P. Sutton, ARPA chief scientist and past ARS President; Brig. Gen. Homer A. Boushey, commander, AF Arnold Engineering Development Center, and a member of the ARS Goddard Memorial Committee; Mrs. Goddard; Dr. Seifert; and Dr. Porter.

Richard W. Porter, GE consultant and past ARS President, and Wernher von Braun, moving force behind the Memorial, pose beside newly dedicated marker.



Moire pattern ($10^6\times$) shows lattice defect in a thin film

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In Print

(CONTINUED FROM PAGE 17)

cludes the book with a review of fact and conjecture about the outer atmosphere of the earth, Mars, and Venus.

All of the papers are well annotated in the typical fashion of scientists giving careful credit to other researchers, and most have a significant number of bibliographic references at the end of the papers.

"Exploration of Space" is a valuable book for the intelligent reader interested in learning just what NASA is about in its many-sided research effort in space. The first reading is interesting and informative. The authors are for the most part figures in our space program or acknowledged experts in various phases of astronomy, or both. Although the subject symposium is more than a year old, it shows little evidence of being dated—other than the absence of reference to subsequent satellites (and reference to the cancelled Vega program in Newell's dissertation).

In passing, the reviewer cannot help but comment upon the title—familiar to most rocket and space types. Physicist Arthur C. Clarke's book of the same title (Harper's, 1952 and since revised) was a national best-seller nearly a decade ago. It is hard to understand why editor Jastrow or the publisher could not have conjured up a new title.

Viewed as a reference work and state-of-the-art survey in the basic research aspects of our space program, "Exploration of Space" is a valuable book for libraries and the individual who wants to know what our space scientists are about.

Fred C. Durant III
AVCO—RAD

BOOK NOTES

Astronautics, already a popular topic with book publishers, is now moving into the record business as well. Possible harbingers of things to come are two new Vox record sets, ably produced by Ward Bostford. **Rockets, Missiles and Space Travel,** written and directed by Wily Ley and, theoretically at least, based on his book of the same title, is a one-record set which offers the countdowns and launchings of various missiles (Atlas, Jupiter, Snark, Honest John, etc.) and interviews with such figures as Wernher von Braun, Krafft Ehricke, Walter Dornberger, John P. Stapp, and Gens. Schriever and Yates. **The Conquest of Space,** a two-record set, consists of a long interview of Dr. von Braun by Ley which begins with a discussion of early experiments by the German Society for Space Travel and proceeds to a discussion of Peenemuende, White Sands, and present and future space experiments. Handsomely packaged, the two sets would seem of interest primarily to educational institutions.

Defense Research and Development Contracts Guide, edited by Jesse L. Lewis (212 pp., Defense R&D Contracts Report, 1420 New York Ave. N.W., Washington 5, D.C., $25), outlines in a clear and straightforward manner the principal contracting agencies of the Department of Defense and gives generally accepted methods for appropriately approaching these agencies to obtain R&D work in the military establishment. Eighty-seven pages of the report are devoted to a listing of agencies by state. Another 37 pages list agencies, offices, and personnel in Washington. There is some general information on programs and current funding. If you are without a guide this is a usable one. It opens no magic doors, however, and your local Small Business Administration office should be able to direct you as well.

RECEIVED

Advances in Aeronautical Sciences, 2 vols. edited by Theodore von Karman, et al, Pergamon Press, New York, 1144 pp., $30.00 the set.

Radio Control for Model Builders by William Winter. John F. Rider, Inc., New York, 220 pp., $4.25, paperbound.

A Beginner's Guide to the Skies by R. Newton Mayall and Margaret W. Mayall. G. P. Putnam's Sons, New York, 184 pp., $2.50.

Physics for Students of Science and Engineering, Part II, by David Halliday and Robert Resnick. John Wiley & Sons, Inc., New York, 470 pp., $6.00.

Elementary Modern Physics by Richard T. Weidner and Robert L. Sells. Allyn and Bacon, Inc., Boston, Mass., 513 pp., $8.50.

Radioisotopes in Science and Industry, A Special Report of the AEC. Govt. Printing Office, Washington 25, D.C., 176 pp., $1.25, paperbound.

Basic Research Resumes—A Survey of Basic Research Activities in the Air Research and Development Command. Herner and Co., U.S. Dept. of Commerce, Washington 25, D.C., 342 pp., $5.00.

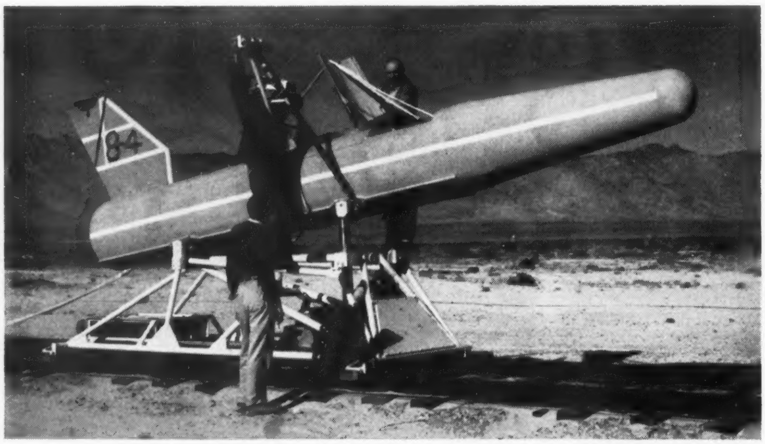
A Multiplet Table of Astrophysical Interest—Revised Edition by C. E. Moore. National Bureau of Standards, U.S. Dept. of Commerce, Washington 25, D.C., 254 pp., $4.00.

Army Research Task Summary 1960, published by OTS, Business and Defense Services Administration, U.S. Dept. of Commerce: **Vol. 1, Medical, Biological, and Social and Behavioral Sciences,** 387 pp., $3.75, PB 161133; **Vol. 2, Chemistry,** 375 pp., $3.75, PB 161134; **Vol. 3, Physics,** Part 1, 400 pp., $3.75, PB 161135; **Vol. 4, Physics,** Part 2, 400 pp., $3.75, PB 161136; **Vol. 5, Engineering,** 420 pp., $4.25, PB 161137; **Vol. 6, Materials Technologies, Mathematics, and Operations Research,** 415 pp., $4.50, PB 161138.

New Plastic Materials Through Government Research (Report PB 161332) by James Kanegis. Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C., 98 pp., $2.25.

Britain's Scientific and Technological Manpower by George Louis Payne. Stanford Univ. Press, Stanford, Calif., 466 pp., $8.50.

Corrosion Data Survey (New Edition) reference work compiled by George A. Nelson. Shell Development Co., Emeryville Research Center, Emeryville, Calif., 50,000 charts and about 500,000 reference points, $50. ◆◆



Swallow Sled Test

Engineers prepare a rocket-sled testing version of the Swallow surveillance drone, being developed by Republic Aviation for the Army Signal Corp., for a 200–300-mph run to evaluate its main parachute system on a track at Edwards AFB in Calif.

TOMORROW...

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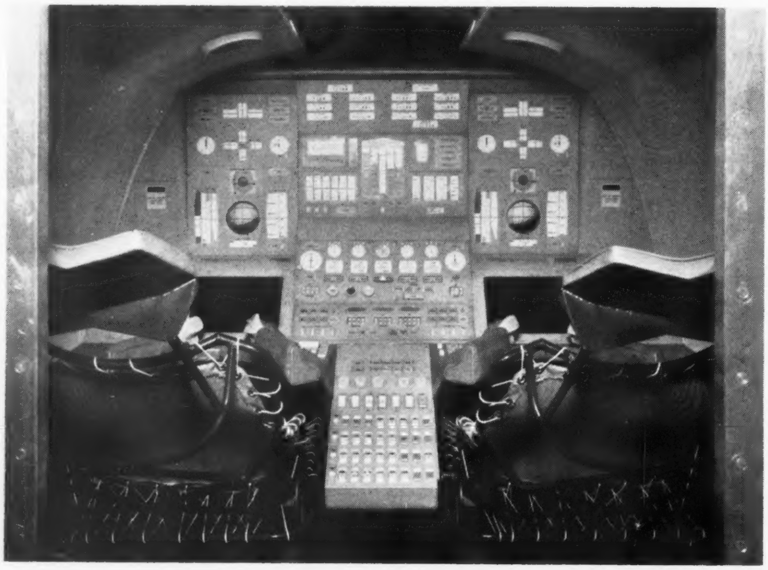


Mark IV Control-Display System developed by Lear Inc. in conjunction with WADD'S Flight Control Laboratory.

Mock-up designed and built by Lear Inc. under a cockpit design study for WADD shows control-display subsystem that after refinement may well be used in future space vehicles such as Dynasoar. Designated Mark IV, the control panel, arranged for optimum viewing and to provide information a pilot would require for safe flight, was recently outlined for the press at Lear's Advance Engineering Div., Grand Rapids, Mich. As the photo shows, there will be dual controls at left and right for pilot and co-pilot, so they can spell each other. The middle grouping is a shared zone containing information pertaining to orbital phase of the mission. The black screen in front of each seat is an optical viewing system for navigational information. The panels are grouped by subsystems: Flight group, viewers, orbital parameters, environment and secondary power, weapons, communications, center console (miscellaneous switches and circuit breakers), and the arm rest controls (attitude and computer controls).

Observation Satellites

(CONTINUED FROM PAGE 33)

(to be discussed here), altitudes measured in thousands of miles from the earth's surface (that is, to tangency) can be obtained with a total viewing angle of about 60 deg from the 4000-mile station. Of course, ground resolution will fall off fast because of the rapidly increasing obliquity of those portions of the earth farthest off the axis of the camera. On the other hand, there is no requirement that the coverage be accomplished with one photograph.

The kind of instrumentation that should be investigated for this specific application is wide-angle photography secured with mapping-type lenses. Standard mapping lenses of 6-in. focal length can cover a 9-in.-square format. Wider-angle lenses are available. The distortionless characteristics of the mapping lens is needed for mapping, but not for cloud observation. Relaxation of this requirement will prove a boon to the lens designer.

A simple calculation will demonstrate the power and usefulness of such a satellite system. Assume a 4000-mile altitude (this puts the satellite on a 4-hr period). Assume further that we are able to achieve 50 lines/millimeter of high-contrast resolution with a 6-in.-focal-length lens of medium wide angle, say of the order of 60 deg. The vertical scale of the photography at this distance is approximately 40,000,000. The formula for ground resolution is

$$G = \frac{\text{scale number}}{300 \times \text{resolution in lines/mm}}$$

With this formula we can readily calculate that a 6-in. lens at 4000 miles producing 50 lines/millimeter yields a calculated ground resolution of about 2700 ft. This will undoubtedly be useful for weather reconnaissance.

An important and little-recognized point must be made concerning the limitations of the single parameter of ground resolution. One can easily bemuse oneself with calculations of lines per millimeter, and the like. As calculations become more sophisticated, workers in the field tend to become skeptical of their absolute value. It is pointed out, for example, that, in general, a given ground resolution obtained at 10 lines/millimeter gives more information than the same ground resolution obtained at 100 lines/millimeter. Furthermore, this criterion, whether measured at high contrast or low, is essentially a measure of performance against the standardized type of line-spaced target.

It says nothing immediately about edges, the imaging of which is of direct concern in cloud photography. It says nothing immediately relevant about the extremely interesting and useful phenomenon by which long lines are imaged despite the fact that the width of the line may be well below the resolution threshold. The photograph from the Viking rocket (April *Astronautics*, page 27) demonstrates this phenomenon vividly. In other words, one must treat such calculations gingerly and with extreme caution; they are only suggestive.

What is required is a set of experiments performed with the aid of photography at known resolutions obtained from satellites, from vertical rockets, and elsewhere. Such photography should then be systematically degraded in the laboratory by accepted techniques to reproduce photography over an entire range of ground resolutions for study and analysis. Only from a rather extensive (but in the long run, inexpensive) series of such experiments can definite criteria be developed for the resolution requirements for weather reconnaissance from satellites.

The technique here is of extreme importance. In general, wide-angle photography with the sun nonnormal to the portion of the surface of the earth being photographed produces cloud shadows. Proper choice of film receptor (for example, infrared) or proper use of a deep red filter (such as a 25A filter) on standard aerial film will result in black cloud shadows giving very good contrast with the edges of the clouds. Resolution numbers simply do not apply easily and conveniently to this aspect of reconnaissance.

It has been hitherto commonly assumed by most meteorologists writing

about weather observation that the only useful parameter which can be produced is cloud distribution and identification by type. Examination of the cloud photographs that are available, paying particular attention to the shadow phenomenon, indicates that careful analysis (which could be standardized and made routine) is capable of yielding cloud heights. Essentially standard photogrammetric techniques applied to such photography will materially aid in the analysis of the photographs, location of the vertical (which is essential to analysis), and the like.

Extensive preoccupation with wide-angle photography as the clue to this type of weather reconnaissance derives from the relatively low information content required and the relative infrequency of photography required. (A picture every 10 or 15 min from orbit might be sufficient.) The possibility exists, therefore, of processing this photography in the satellite, using a channel of relatively low information rate for transmission. In general, this is an easier problem with respect to both data acquisition and transmission than the corresponding problem for the inspection satellite.

It would seem clear that fairly wide-angle photography from rather extreme altitudes would furnish very good ties on successive orbital passes, and, with good orbital information, would permit study of the shifting patterns between orbital passes, especially in the region of overlap. A sample calculation will make this clear. Suppose that the satellite is on a polar orbit, at 4000-mile altitude, with a 4-hr period. At the equator, the earth would move 4200 statute miles between successive passes of the satellite. In the mid-latitude region, say 45 deg, this movement is about 3000 miles; but at 4000-mile altitude a wide-angle camera system can easily cover one and one-half times the 4200 miles. Hence, complete coverage is assured, and a good tie between successive passes is easily accomplished. It seems possible that speed of cloud movement may be obtained by this technique.

In principle, the wide-angle mapping-type system discussed above is available now. New mapping lenses capable of yielding resolutions such as those used in the foregoing calculations are available. This fortunate circumstance is a byproduct of the low ground resolution requirements of this system. For example, suppose that exposure time were $^1/_{500}$ sec. In that time ground motion as seen from the satellite is down in the noise level compared with the ground resolution required, and thus may be ignored. Of course, angular motion must be kept to a minimum. The very long lever arm at, say, 4000 miles would produce high-speed image motion in the direction of angular motion of the satellite.

The particular format used above—9 x 9 in.—is not the only useful camera size. Consider, for application to this particular problem, a camera using 70-mm film whose format is, say, $2^1/_4$ x $2^1/_4$ in. This is a photo of the size produced by many well-known amateur cameras. Now let us use a 1-in.-focal-length lens, and assume that we can get the same resolution as before—50 lines/millimeter. We will also assume an altitude of 500 miles. Ground resolution, as calculated above, will be about 2000 ft. The area covered per single photograph will be somewhat more than 1125 miles on a side—approximately 1,266,000 sq mi. If this 500-mile-altitude satellite is on a polar orbit, there will be gaps in coverage at the equator, with increasing overlap between the ground areas covered on successive passes, as the satellite departs from the equator.

In principle, this particular camera system would have to take about 12 photographs per pass, which, with about 14 orbital circuits per day, makes for about 168 photos per day. This would require about 35 ft of 70-mm film per day. Six months of operation would require somewhat over 6000 ft of film—not an unreasonable load.

In the discussion of the 24-hr satellite in the July issue, the use and advantages of this particular orbit for meteorological observation are discussed.

Photographic systems are not necessarily the only ones useful for cloud observation. Television systems seem to have a natural application to this type of mission, and have been widely discussed, publicized, analyzed, and programmed. However, one of the purposes of this discussion is to raise the possibility that the tasks of meteorological observation might be accomplished at least as well, and perhaps much better, by photographic techniques than by TV techniques.

Tiros System

The NASA meteorological satellite (Tiros) program, originally begun by ARPA, is based on the use of RCA vidicon TV cameras, operating at 300 miles. Resolution, in the terms used in this paper, is about 3 miles.

Such evidence as is at hand indicates that ground resolutions of the order of several miles may be useful in determining gross cloud cover or lack thereof. Identification of cloud types requires ground resolution better by an order of magnitude. This is the promise of the photographic method.

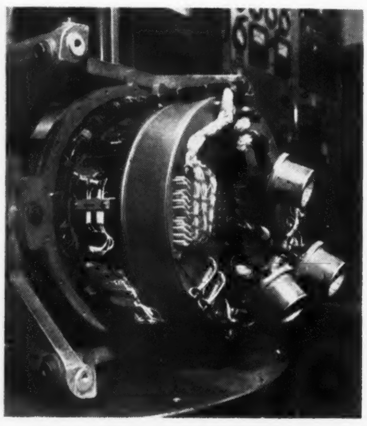
Two composite rocket photos taken on the same day by two different vehicles are shown on pages 32–33. The upper photo was made from a series of 4- x 5-in. photographs ($6^3/_8$-in.-focal-length lens) taken from a V-2 near a 60-mile altitude at about 11:05 a.m. MST and covers the southwest and northwest quadrant. The lower photo was taken from an Aerobee rocket near 70-mile altitude at about 9:50 a.m. MST, and covers a north-south strip from Wyoming to Mexico.

These photographs are of historic importance for satellite meteorology. The photographs were probably of about 10 lines/millimeter quality and, with the long slant ranges and large cosine effects, exhibited very poor ground resolution at midrange and extreme range. The photos have been extensively analyzed by Prof. S. Bjerknes.

One other major use for observation satellites would, of course, be for inspection purposes.

Proposals for and discussions of aerial inspection systems as an integral part of atomic energy controls were made as early as 1947, in a UN report. Since that time, proposals for the use

State of the Art



Shown with its gold-plated cover removed, the reference section for Titan exhibits the compactness of advanced guidance systems. Titan guidance features an advanced version of the "strap-down" concept, in which the gyros are fastened rigidly to the frame of the missile and react to preset time signals and external commands. The reference sections consist of three hermetic integrating gyros (HIG-4S), a pitch and roll programmer, and an electronically controlled timer. The covered drum-like section is the timer.

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of aerial inspection systems, alone or in conjunction with ground inspection systems, have been advanced as part of larger proposals in the fields of disarmament and warning against surprise attack.

The constitution, composition, and operation of such systems have not yet been agreed on. It is, or should be, clear, that observation satellites may have a role to play in any inspection system.

An observation satellite containing an infrared viewing system can probably be used to detect and pin-point missile firings, serving either to monitor agreements regarding such firings or to assist in removing considerable surprise from an intended surprise attack. The use of infrared detectors in satellites for the detection of missiles early in their trajectory, as they leave the earth's atmosphere, is under active study (Project Midas).

Observation satellites with visual sensing equipment can be used as part of a system (which may also employ aircraft) to perform installation inventory, to warn of slower-paced mass attacks, i.e., slower than a mass missile attack, to assist ground inspectors in locating previously unknown sites, to monitor shipping, etc.

Detailed descriptions of particular kinds of observation satellites are not germane to this argument. Earlier sections of this series indicate that sooner or later extremely high-resolution satellites can be available. What is important is that the emergence and application of observation satellites will make inspection inevitable.

The idea of employing observation technology for such purposes has been discussed openly and widely. Not all available references need be cited to establish this point. The following references are quoted because of their relevance, and to demonstrate that the application of observation technology to inspection problems is not a new idea.

In an article published in January 1955, Col. R. S. Leghorn says:

> "The United Nations might also consider developing surveillance satellites in a high priority program. When they are operating successfully, electronic receivers could be located in the surveillance center of the UN Assembly. These satellites which would circle the world every few hours, would regularly scan all significant areas of the earth . . ."

And from an article on AF photography in 1948:

> "What of the future? Not stated previously is the long-term photographic reconnaissance goal—the recording and transmission to a home station, from an uninhabited aircraft, and under all weather conditions, the ground detail below the aircraft.
>
> "Our mapping people will have no surcease from their labors until the earth is completely, accurately, and precisely mapped and until it is possible to quickly remap any portion of the earth's surface . . . It may not be amiss to

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point out that further developments of the very same philosophy so easily and successfully employed in war can be as easily, and it is hoped, as successfully employed in the maintenance of peace, in continual and continuous inspection of large areas, as required in any system of international atomic controls, and in all the other numerous activities of peaceful peoples."

The final report of the Subcommittee on Disarmament of the Senate Foreign Relations Committee, 85th Congress, makes the following point, among others in Section VII, on *Arms Control in the Space Age:*

"22. *International cooperation for peaceful space exploration and development.*—Under the auspices of the International Geophysical Year the nations of the world are already cooperating to a limited extent for peaceful scientific study and exploration of space. This cooperation should now be carried onto a higher plane through a formal international organization providing for intergovernmental action under the United Nations. Peaceful cooperation of this nature would have positive value as a means of diverting resources and energies that might otherwise be available for military space projects. One of the first projects should be the development of a reconnaissance satellite to assist in carrying out arms control measures."

In congressional debate on Feb. 4, 1958, Sen. Carroll (Colorado) said:

"We talked of . . . the possibility of an inspection deterrent through high-powered, sensitive cameras in orbiting, controlled space vehicles."

Subsequently, a comment in the same debate was made by Sen. Hubert Humphrey (Minnesota):

" . . . It is important for our Government to know what we mean by 'inspection,' if we are to continue to talk about it . . . We should also be investigating to what extent the achievements of the launching of earth satellites will affect present plans for aerial inspection to prevent surprise attack.

"I digress to comment upon what the distinguished junior Senator from Colorado (Mr. Carroll) had to say today about the type of aerial photography which is presently available and is known to be in existence, and how aerial photographic equipment might well be utilized, as he indicated, with outer space objects or satellites.

"The United Nations should establish a special committee on the joint exploration of outer space—a committee which should include the scientists of many nations, including those of the United States and the Soviet Union. Such an act would constitute a truly new enterprise in genuine international cooperation. One of the first projects such a committee might sponsor could be a United Nations reconnaissance satellite. A satellite of this nature would impress all nations that no longer are national borders and countries sacrosanct. It would be a vivid example of internationalism which by its very existence would require the creation of new concepts of international law and order. Why not let the most important international organization dedicated to peace be the sponsor of a special kind of an earth satellite? This would be science at work for humanity, not nationality."

Meetings between Western and Eastern Blocs were held in Geneva in November and December 1958, to consider technical aspects of the problem of preventing surprise attack. The full title of the meeting is part of the report title which was issued Jan. 5, 1959: *Report of the Conference of Experts for the Study of Possible Measures Which Might Be Helpful in Preventing Surprise Attack and For the Preparation of a Report Thereon to Governments.* Annexes 6, 7, and 10 of this report are of direct relevance to this discussion. Therein are discussed the usefulness and role of satellites in observation and inspection of the instruments of surprise attack, in particular, aircraft and ballistic missiles.

In the report (Annex 6, page 5), it is stated that the major uses of photography are to provide information to: (1) Determine installation inventory; (2) warn of localized surface attack; (3) verify the validity of "force data" exchange; (4) provide strategic warning through force disposition and buildup; and (5) provide data required for planning for ground inspection systems.

This important reference gives estimates of the ground resolution required for each of the separate tasks, discusses the possible use of radar in observation satellites, and furnishes valuable data for further analysis and consideration of the inspection problems.

The use of satellites for detection of high-altitude nuclear explosions as part of an inspection was suggested by Hans Bethe, and was commented on as being feasible by Hugh Dryden of NASA. The satellite would be instrumented with radiation detection gear to record the radiation emitted by a high-altitude nuclear burst. The necessary instrumentation for this application bears no resemblance, of course, to the observation as emphasized in this paper; but, because it does relate to inspection satellites, it is included here.

References

Widger, W. K. and Touart, C. N., "Utilization of Satellite Observations in Weather Analysis," *Bulletin of the American Meteorological Society*, Vol. 38, No 9, 1957, pp. 531–533.

Wexler, H., "Observing the Weather From a Satellite Vehicle," *Journal of the British Interplanetary Society*, Vol 13, 1954, pp. 269–276.

National Aeronautics and Space Act, Hearings Before the Special Committee on Space and Astronautics, U.S. Senate, 85th Congress, 2nd session, Part 2, H. Wexler, p. 369.

"Missile and Space Activities"—Joint Hearings Before the Committee on Armed Services and the Committee on Aeronautical and Space Sciences, U.S. Senate, 86th Congress, 1st session, Jan. 29 and 30, 1959, p. 191.

"Meteorological Satellite," *Aviation Week*, April 20, 1959, p. 28.

Stroud, W. G. and Nordberg, W., "Meteorological Measurements from a Satellite Vehicle," Chap. 13 of Scientific Uses of Earth Satellites, edited by J. A. Van Allen, Univ. of Michigan Press, 1956, pp. 119–132.

Greenfield, S. M. and Kellogg, W. W., "Weather Reconnaissance by Satellites," *Astronautics*, Vol. 4, No. 1, January 1959, pp. 32–33, 77–78.

"The Next Ten Years in Space: 1959–1969," Staff Report of the Select Committee on Astronautics and Space Exploration, 86th Congress, 1st session, Dr. F. W. Reichelderfer, pp. 135–144.

Bjerknes, J., "Detailed Analysis of Synoptic Weather as Observed from Photographs Taken on Two Rocket Flights Over White Sands, New Mexico, July 26, 1948," The Rand Corp., Paper P-887, April 1951.

Second Report to the Security Council, UN AEC, Sept. 11, 1957, (AEC/36, Sept. 11, 1947), Part II.

"Missile and Space Activities," Joint Hearings Before the Preparedness Investigating Subcommittee of the Committee on Armed Services and the Committee on Aeronautical and Space Sciences, U.S. Senate, 86th Congress, 1st session, Jan. 29 and 30, 1959, pp. 187–192.

"No Need to Bomb Cities to Win War" by Col. Richard S. Leghorn, *U.S. News and World Report*, Jan. 28, 1955, pp. 78–94.

Leghorn, Col. Richard S., "U.S. Can Photograph Russia From the Air Now," *U.S. News and World Report*, Aug. 5, 1955, pp. 70–75.

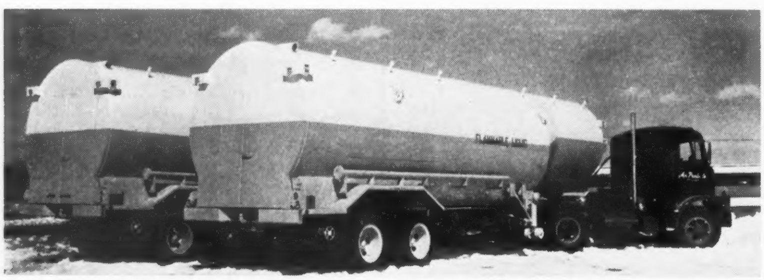
Final Report, Subcommittee on Disarmament, Committee on Foreign Relations, U.S. Senate, 85th Congress, Sept. 3, 1958, p. 15.

The Congressional Record, Vol. 104, No. 18, Feb. 4, 1958, p. 1389.

The Congressional Record, Vol. 104, No. 18, Feb 4, 1958, pp. 1401–02.

"Report of the Conference of Experts for the Study of Possible Measures Which Might Be Helpful in Preventing Surprise Attack and for the Preparation of a Report Thereon to Governments"; United Nations General Assembly A/4078, S/4145, Jan. 5, 1959. ♦♦

The concluding part of this series, to appear in an early issue, will discuss probable trends in observation satellites and increased sizes and capabilities.



Liquid-Hydrogen Transports

Two of four 7000-gal tank trailers for transporting liquid hydrogen, the fuel for Centaur and Saturn upper stages, coast to coast. Designed and built for the Air Force by Air Products, Inc., the trailers are constructed like huge thermos bottles, with an inner chamber, holding over 2 tons of liquid, suspended inside an outer shell.

ASTRONAUTICS Data Sheet — *Propellants*

Compiled by Stanley Sarner, *Flight Propulsion Laboratory Dept., General Electric Co., Cincinnati 15, Ohio*

WHITE FUMING NITRIC ACID (WFNA)

WFNA is essentially pure nitric acid. The allowed deviations from purity, as given by MIL-N-7254 B,C, are shown in the bottom table for both the "inhibited" and "uninhibited" acids. The pure acid and acid-water mixtures are colorless. However, the presence of small amounts of NO_2 due to decomposition leads to a yellowish tinge and the characteristic irritating odor.

Since WFNA is not a pure compound, most of the physical and chemical properties listed in the accompanying tables are those for pure HNO_3. The variance due to the water and N_2O_4 present in WFNA is not great, but will depend on the actual sample used.

Hazards

WFNA is very corrosive and contact with human tissue results in yellow staining followed by severe chemical burns. Protective clothing, including rubber hood, rubber apron, rubber boots, and acid-handling gloves, must be worn. Flushing with large amounts of water is recommended when contact does occur. This should be followed by medical attention. WFNA vapors may contain NO_2 which is quite toxic. The maximum allowable concentration in air, based on the NO_2 content, is 5 ppm. Higher concentrations of WFNA may be allowed if the NO_2 concentration is lower.

Materials for Handling

The use of about 0.6 per cent HF as an inhibiting agent in WFNA reduces the corrosion of stainless steels and aluminum to a negligible amount. The use of aluminum (2S, 3S, and 3003, particularly, and also 1060, 1100, 3004, 6061, and 5052) is recommended at ambient temperatures, and the 300 series stainless steels (especially 347, 304, and FA-20) at higher temperatures. High silicon irons (Duriron, anticiron) are almost immune to attack by WFNA and may be used wherever their poor mechanical properties can be tolerated. The latter should not be used where HF is present. Titanium should be avoided, since it presents an explosion hazard in contact with WFNA.

Suitable nonmetallic materials are Teflon, Kel-F, compressed asbestos, Genetron plastic HL, Noroseal 147-S, Fluorolube, and other fluorocarbons. Lubricants should be checked for nitratable contaminants.

Cost and Availability

WFNA is readily available in very large quantities at about 3¢/lb in tank car lots. The annual production of anhydrous nitric acid exceeds 2 million short tons.

Physical Properties of WFNA*

Boiling Point	84 C	183 F
Freezing Point	−41.59 C	−42.86 F
Specific Gravity (MIL-N-7254 B,C)	60 F/60 F	1.511-1.525
Density at 0 C (32 F)	1.548 g/cm³	96.63 lb/ft³
at 25 C (77 F)	1.503 g/cm³	93.81 lb/ft³
Vapor Pressure at 0 C (32 F)	0.019 atm	0.278 psia
at 25 C (77 F)	0.082 atm	1.209 psia
at 50 C (122 F)	0.276 atm	4.061 psia
Viscosity at 0 C (32 F)	1.110 centipoises	—
at 25 C (77 F)	0.733 centipoises	—
Thermal conductivity at 17.2 C (63 F)	—	0.13 Btu/ft-hr-F
Thermal conductivity** at 0 C (32 F)		0.155 Btu/ft-hr-F
at 25 C (77 F)		0.163 Btu/ft-hr-F
at 50 C (122 F)		0.170 Btu/ft-hr-F
Boiling Point		0.180 Btu/ft-hr-F

* Values are for 100% HNO_3 unless specified.
** For WFNA: HNO_3 = 99.01%, N_2O_4 = 0.46%, H_2O = 0.53%.

Chemical Properties of WFNA*

Heat of Formation (liquid) at 25 C	−41.404 kcal/mole
Heat of Vaporization at 25 C	9.353 kcal/mole
at boiling point	8.569 kcal/mole
Heat of Fusion at freezing point	2.503 kcal/mole
Heat Capacity at 25 C	26.25 cal/mole-C
Maximum Allowable Concentration in air*	5 ppm

* Values are for 100% HNO_3, except that the MAC is based on the N_2O_4 present.

Theoretical Performance of WFNA*

Fuel	Specific Impulse (sec) Frozen Flow	Specific Impulse (sec) Equilibrium Flow	Chamber Temperature Deg K
NH_3	261	270	2700
N_2H_4	270	275	2900
Octane	256	265	3000
UDMH	266	275	3100

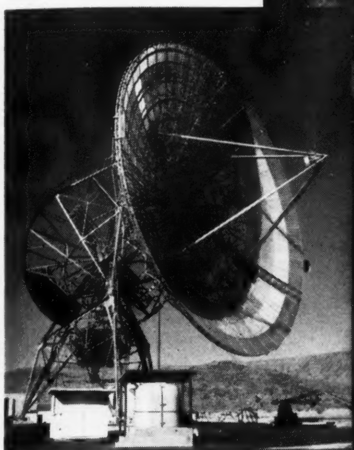
* Pc = 1000 psia; P_e = 14.7 psia; optimum O/F ratio. Figures are approximate and not overly reliable. Chamber temperatures correspond to equilibrium flow impulse.

Composition of WFNA (MIL-N-7254 B, C)

	Uninhibited-I	Inhibited-IA
HNO_3	97.5% min	96.8% min
Water	2.0% max	2.0% max
N_2O_4	0.5% max	0.5% max
Total solids as nitrates	0.1% max	0.1% max
HF	—	0.6 ± 0.1

Pioneering Achievements at JPL

Following an impressive period, beginning in 1938, in the pioneering and development of all forms of rocketry—JPL's jump into outer space began with the successful flight of America's first satellite, Explorer I. When the moon probes Pioneer III and IV proved equally successful, the Jet Propulsion Laboratory's position as an outstanding center of research and development was again confirmed.



RECEPTION

The 85 foot parabolic antenna at Goldstone, California built in 1958 and used in tracking and recording telemetry from U.S. spacecraft.

TRANSMISSION

This 85 foot antenna, 7 miles from the reception facility, has recently been put in operation to transmit signals to U.S. spacecraft.

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The purely scientific data produced by such a facility ranges from propagation data and lunar reflectivity characteristics to the wideband data communicated to the station from the scientific instruments aboard the space probes. This is but one of the many space exploration activities pioneered by the Jet Propulsion Laboratory.

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(CONTINUED FROM PAGE 29)

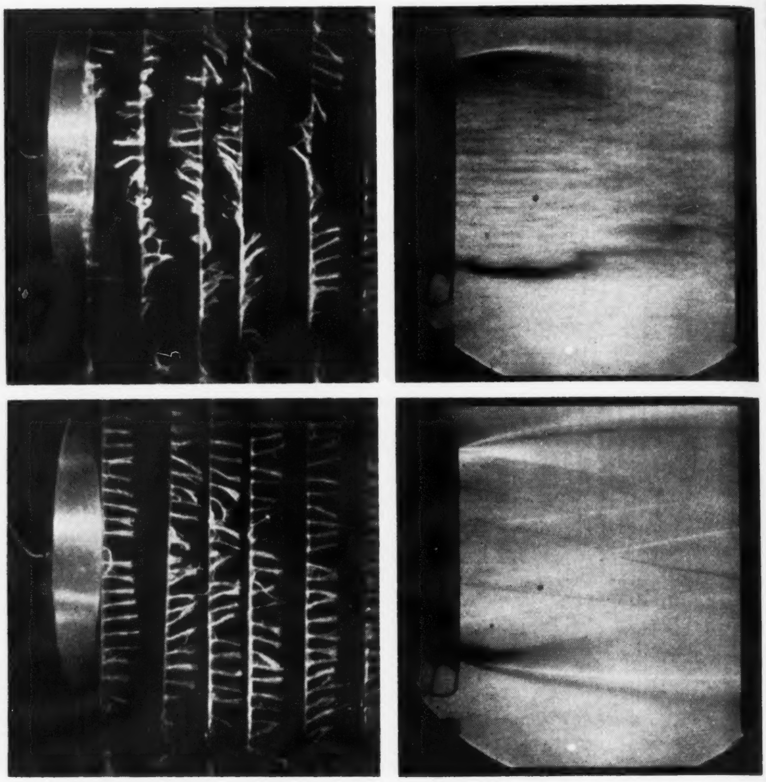
ratio of 34.2 and a length of half that of a 15-deg conical nozzle. The photo on page 29 shows the nozzle with its central plug. The nozzle wall and the rear face of the plug were instrumented to measure static pressures. A series of runs were made at various pressure ratios across the nozzle, and during each run the pressures on the nozzle wall and the rear face of the plug were measured. Preliminary investigations showed that the pressure on the rear face of the plug is slightly lower than ambient and depends upon the pressure ratio across the nozzle. Pressure measurements taken on the wall at both high and low pressure ratios across the nozzle showed close agreement with the type of distribution indicated in the first sketch below. The location and trend of the pressure rise due to the compressive turning on the nozzle wall, estimated from the pressure on the plug rear face, was substantiated by the experimental data.

The nozzle exit flow during these tests was studied by means of Schlieren photographs of the flow and motion pictures of tufts attached to wires stretched across the flow. Typical Schlieren photographs taken at low and high pressure ratios are shown at right. In both the cases the flow can be seen attached to the nozzle walls. The shock waves visible in the photograph taken at the high pressure ratio indicate a flow pattern similar to the E-R type shown among the three sketches on page 29. The void region in the center of the nozzle at low pressure ratio is evident by the tuft pattern shown at top left. There is actually a certain amount of eddy flow in the reverse direction in this region. The tufts at high pressure ratio condition indicate full flow through the nozzle.

An experimental rocket engine with an E-D-type nozzle was built and successfully tested using a Lox-RP propellant combination. The nozzle contour was designed for an area ratio of 41.2 and a length 41 per cent that of a 15-deg conical nozzle. The over-all exit diameter of this nozzle was 70 in., whereas the length from throat to exit was only 45.2 in. Theoretical analysis of flow through this nozzle indicated that even though its length is only 41 per cent of a 15-deg conical one, a calculated vacuum thrust comparable to that of a conical nozzle can be achieved. The two photos on page 28 show ignition and full operation of the E-D rocket-engine test at Rocketdyne's Santa Susana facilities. The data obtained during these sea-level tests showed that the predicted vacuum thrust performance can be achieved. The wall pressures measured confirmed the compressive turning on the nozzle wall and the associated pressure rise, as described by the first sketch on this page.

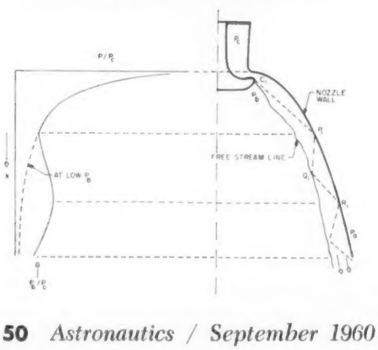
The E-D nozzle represents an advance in rocket design. For the same thrust as a conventional bell nozzle, the E-D nozzle need be only half as

Schlieren and Tuft Photos of Blow-Down Tests

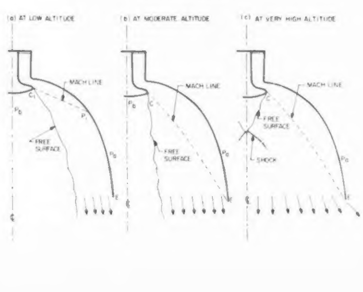


Top, left and right, tufts and free jet at low pressure ratio; bottom, left and right, tufts and free jet at high pressure ratio.

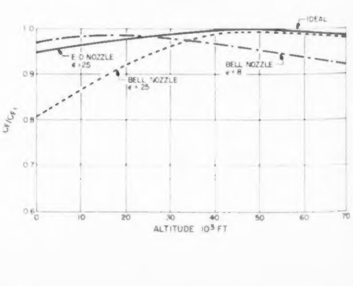
Effect of Ambient Pressure on Wall Pressure Distribution



E-D Nozzle Flows at Various Altitudes



Estimated Performance of an E-D Nozzle



long. The absence of thrust loss associated with over-expansion makes the E-D nozzle efficient over a wide range of operating pressure ratios, suiting it especially for boosters and single-stage ballistic missiles. Reduction in nozzle length, and hence the savings in weight of interstage structure, suggests the use of E-D contour for upper-stage engines, where large area ratios are needed. The cold-air blow-down tests and hot firings of an experimental rocket engine have verified the operating principle of the E-D nozzle and its merit at low operating-pressure ratios.

Suggested Additional Reading

Rao, G. V. R., "Exhaust Nozzle Contour for Optimum Thrust," *Jet Propulsion*, Vol. 28, June 1958.

Berman, K., "The Plug Nozzle: A New Approach to Engine Design," *Astronautics*, April 1960.

Rao, G. V. R., "Spike Nozzle Contour for Optimum Thrust," presented at the 4th BMD Symposium, Los Angeles, 1959.

Beale, W. T. and Pavolny, J. H., "Internal Performance of Two-Dimensional Wedge Exhaust Nozzles," NACA RM E56K29b, Feb. 28, 1957. ♦♦

ARS Goddard Memorial

(CONTINUED FROM PAGE 34)

Goddard had been an ARS Board Member at the time of his death, and that it was another ARS Board Member, Dr. von Braun, who had suggested that an ARS memorial to Dr. Goddard at this historic site would be appropriate.

Dr. von Braun commented that Dr. Goddard had been his boyhood hero and it was only natural when he came to this country that he should want to see the place where he had performed his early experiments. He contrasted rocketry today with rocketry in Dr. Goddard's day, noting that what we have now would not have been possible had it not been for a few pioneers—lonely men, working by themselves, without financial support or assistance, who exposed themselves to laughter and ridicule because of their belief in rockets. Dr. Goddard, he added, was one of the very few men who met the challenge.

"It is the Kitty Hawk of rocketry which we commemorate here today," he stated, "and it may in the long run prove to be even more important than the Kitty Hawk of aviation."

Mrs. Goddard recalled the fateful day of the flight and all of the disappointments, as well as joys, which had marked Dr. Goddard's experiments in the Auburn-Worcester area, noting that his Aunt Effie Ward had allowed him to use her property first for his solid rocket experiments and later for liquid rocket launchings. Mrs. Goddard also reminisced over the historic 1926 flight, witnessed by only four people, which she herself had photographed.

The dedication program was introduced by F. C. Durant III, director of public and government relations, Avco Research and Advanced Development Div., past ARS President, and chairman of the ARS Goddard Memorial Committee. Other members of the committee were: G. Edward Pendray, ARS Founding Member and past President; Brig Gen. Homer A. Boushey, commander, AF Arnold Engineering Development Center; and James J. Harford and Irwin Hersey of the ARS headquarters staff.

Prominent guests present, in addition to those already mentioned, were: Robert C. Truax of Aerojet, past ARS President, under whose regime the project got under way; George P. Sutton, ARPA chief scientist and past ARS President; John Shesta, past ARS President and a leading figure in early ARS rocket experiments; Richard W. Porter of GE, past ARS President; Harry P. Goett, director of NASA's Goddard Space Flight Center; Kurt Stehling of NASA; Paul Garber, director of the National Air Museum of the Smithsonian Institution; and Nils T. Ljungquist, long-time associate of Dr. Goddard in his experiments.

Site Deeded to Mrs. Goddard

The land on which Dr. Goddard performed his early experiments in Auburn is now owned by Asa M. Ward, who deeded over to Mrs. Goddard the plot of land on which the marker indicating the site of the launching was erected. Since the site now lies on a golf course, it was decided to use a simple vertical shaft at this spot and put a memorial tablet near the road.

The marker reads: "Site of launching of world's first liquid propellant rocket by Dr. Robert H. Goddard. 16 March 1926."

The memorial tablet reads: "On March 16, 1926, Dr. Robert H. Goddard launched the world's first liquid propellant rocket from a point 1000 feet S.S.E. of this tablet on the property of the Asa M. Ward family. Erected by the American Rocket Society July 13, 1960, in recognition of this significant achievement in the evolution of astronautics." ♦♦

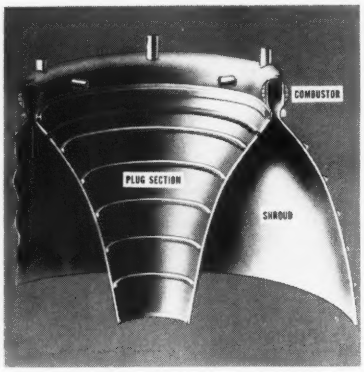
Plug-Nozzle Flexibility

(CONTINUED FROM PAGE 31)

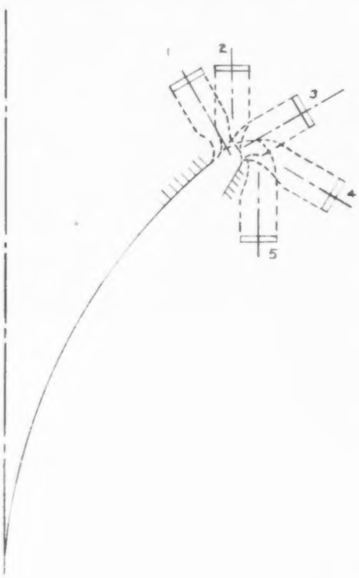
It is clear that the application of the segmented annular combustor permits a large variety of propulsion-system perturbations. However, it is possible to define general areas of maximum utility for the plug configurations which have been described.

The completely external-expansion (Type A) and partial-internal-expansion (Type B) plugs provide the greatest advantage in booster or first-stage application (relatively low nozzle area ratios), while the completely internal-expansion plug (Type C) should find its greatest utility in upper-stage (high area ratio) propulsion units. Type A and Type B offer aerodynamic performance gains over the conventional convergent-divergent nozzle, while Type C does not. However, as shown in the graph on page 31, at high area ratios the Type C configuration provides a decided weight and height advantage relative to the other plug configurations and the conventional design. The illustration at top of this page shows a cross section of such a Type C upper-stage unit.

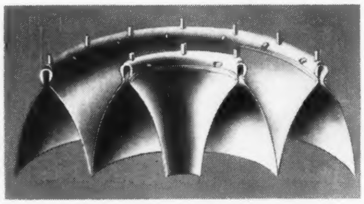
Type C Upper-Stage Engine



Combustor Orientations



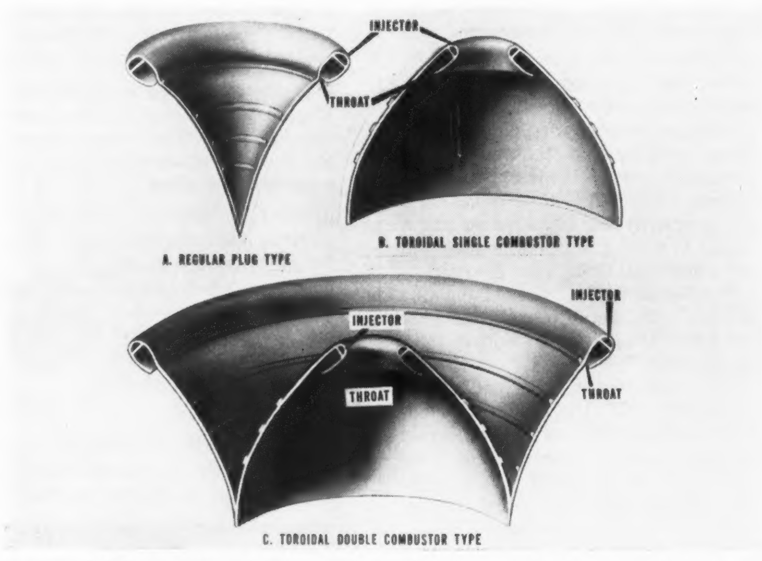
Double Toroidal Unit



The partial-internal-expansion plug configuration is somewhat longer than the completely external-expansion plug; but it provides better aerodynamic thrust-vector capability and a cleaner external aerodynamic surface and orientation.

Insofar as the structural shapes are concerned, it appears probable that the regular plug type (Type A) will be used in thrust ranges perhaps up to about 5,000,000 lb. At higher thrust, toroidal configurations will become more prominent. The sketch at left denotes a double toroidal upper-stage unit in cross section, and the sketch on page 30 shows a double toroidal booster configuration for extremely high thrust levels.

From these few examples, it can be surmised that the plug-nozzle engine, encompassing many different configurations, allows the vehicle designer great latitude and flexibility in optimizing his design. ♦♦



Structural differentiation of plug nozzles, using the completely external plug type as an example.

Mitsui Establishes Rocket Company

The five Mitsui Group defense industry companies—Tokyo Shibaura Electric, Greater Japan Celluloid, Japan Steel, Fuji Heavy Industries, and Tokyo Instruments—together with Mitsui Bussan (Mitsui Trading), and using the MS (Missiles and Space Research) Committee (chairman, Tokyo Shibaura president Fumio Iwashita) as the focal point, agreed at a spring meeting of the Executive Council to invest in a new company, the Japan Rockets Mfg. Co., for the production of the Hawk, Lacrosse, and other missiles of interest to Japan's Defense Agency.

The new company's production will be geared to the Japanese Defense Agency's second five-year plan, but observers are surprised that the Mitsui Group, notoriously weak in heavy industry, should be forging ahead of the Mitsubishi and Kawasaki groups.

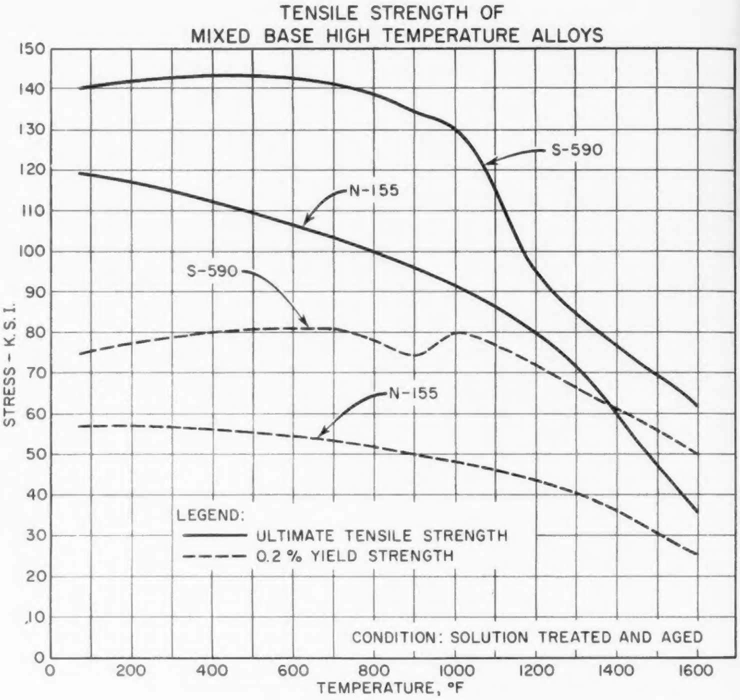
Among the six companies of the Mitsui Group, Mitsui Bussan has technical tie-ups with Raytheon, the maker of Hawk, and Martin Co., maker of Lacrosse, and is also the agent in Japan for radar equipment.

For the present, the Mitsui group will concentrate on the Defense Agency's program for domestically producing the Hawk and Lacrosse missiles; but, in the future, it hopes to join with American missile makers in servicing of missile bases in the various Southeast Asian countries.

—Yoshiko Miyake

ASTRONAUTICS Data Sheet — *Materials*

Compiled by C. P. King, *Materials and Process Section, The Marquardt Corp., Van Nuys, Calif.*



MIXED-BASE ALLOYS S-590 AND N-155

These materials have been used more than 10 years for their excellent properties and stability up to 1400 F in long-term applications and up to 2000 F in short-term applications. Corrosion resistance and oxidation resistance are excellent.

Fabrication

Both of these alloys as sheet may be formed by all conventional methods. Higher pressures must be used than for stainless steel, and more frequent intermediate anneals are necessary because of work-hardening tendencies.

Forging and casting techniques are standard. Vacuum melting of metal for castings may improve properties, but the process is not usual.

Machining is a little difficult and requires low feeds and speeds. Ample cooling and avoidance of work-hardening are necessary. The aged condition is preferred for machinability.

Joining

Both of these alloys may be fusion- and resistance-welded. Joint efficiencies are good.

Applications

Turbine blades, wheels, and rotors have made extensive use of S-590 and N-155. Jet exhausts and thrust reversers also employ them for their oxidation resistance. High-temperature bolts have also been fabricated.

Available Forms

Both alloys are available as bar, forgings, sheet, plate, weld rod, tube, wire, and sand and investment castings.

Physical Properties

	Density, lb/in.^{3}	Thermal Conductivity, Btu/sq ft/in./hr/F			Coefficient of Thermal Expansion, in./in./F			
		400 F	800 F	1200 F	400 F	800 F	1200 F	1600 F
S-590	0.301	101	125	149	8.0	8.2	8.7	9.2
N-155	0.300	107	132	154	8.4	8.8	9.5	10.0

Heat Treatment

Treatment	S-590	N-155
Solution Treatment	2150–2250 F, 1 hr	200–2300 F, 1 hr
Quench	Air or water	Air, oil, or water
Age	1350–1500 F, 10 hr (min)	1200–1650 F, 4 to 24 hr

Chemical Composition (%)

	C	Cr	Ni	Mo	Cb+Ta	W	Co	N	Fe
S-590	0.38–0.48	19.0–22.0	18.5–21.5	3.5–4.5	3.5–4.5	3.5–4.5	18.5–21.5	—	Balance
N-155	0.08–0.16	20.0–22.5	19.0–21.0	2.5–3.5	0.75–1.25	2.0–3.0	18.5–21.0	0.10–0.20	Balance

CUT ALONG THIS LINE

NEW!

HONEYWELL VISICORDER MODEL 1406*

direct-recording oscillograph

A fourth outstanding instrument has joined the Honeywell Visicorder family—the new Model 1406, an efficient, dependable direct-recording oscillograph capable of recording up to six simultaneous dynamic functions and producing immediately readable permanent records without inks, styli, heat, powders, or chemical processing.

Designed to take full advantage of the ultra-violet Visicorder principle, the 1406 provides today's most advanced recording method at an extremely reasonable price. For only $1845, you can own a complete six-channel Visicorder, including galvanometers, grid line system, and built-in timer, while a two-channel model is available for just $1255. Because it is less complex than other Visicorder models, the 1406 greatly reduces the per-channel cost of acquiring and recording data.

*Prices range from $1145 to $1845

ARS news

At head table banquet night, left to right: Alexis W. Lemmon Jr. of Battelle Memorial Institute, program co-chairman; George R. Gehrkens, vice-president of NAA's Columbus Div.; Peter L. Nichols Jr. of Stanford Research Institute; James L. Harp, president of the Columbus Section; Col. George P. Hollstein, professor of air science at Ohio State Univ.; Roy Marquardt, president of Marquardt Corp. and the evening's guest speaker; Loren E. Bollinger, general chairman of the conference; William H. Yahn, president and general manager of NAA's Columbus Div.; Col. Frank J. Seiler, director of science for ARDC; Bertram Thomas, president of Battelle Memorial Institute; Brooks Morris of Marquardt, coordinator of ARS Technical Committees; G. L. Von Eschen, chairman of Ohio State's Aeronautical Engineering Dept.; and Martin Goldsmith of Rand Corp., also program co-chairman.

Propellants, Combustion, and Liquid Rockets Conference Held at Ohio State Univ.

Columbus, Ohio—Some 400 engineers and scientists gathered here on July 18–19 for the second ARS specialist meeting on propellants, combustion, and liquid rockets to be held at the Ohio State Univ. This year's meeting was under the general chairmanship of Loren E. Bollinger of Ohio State with Alexis W. Lemmon Jr. of Battelle Memorial Institute and Martin Goldsmith of the Rand Corp. as program co-chairmen. It was sponsored by the ARS Propellants and Combustion and Liquid Rockets Committees, chaired by Peter L. Nichols Jr. of Stanford and Martin Goldsmith, respectively.

Registration started on Sunday in the Ohio Union. Dual sessions began on Monday, July 18. The two concurrent sessions, used throughout the two-day meeting, were planned with the idea that the conferees probably would want to attend one session or the other.

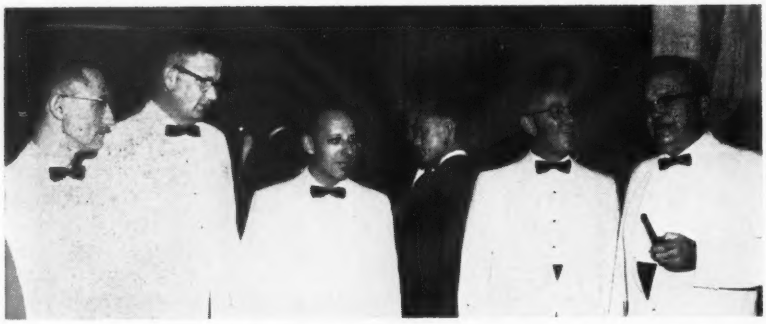
Paul Castenholz of Rocketdyne got the session on liquid rocket engine components under way with a paper by Ernest Mayer, also of Rocketdyne, concerning the pressure feasibility limits in regenerative cooling. He showed that regenerative cooling is feasible only if the combustion pressure is below a certain limiting value. Details of the X-15 turbopump were given by S. R. Matos from Reaction Motors Div. of Thiokol. C. Kaplan of Rocketdyne considered the problem of selecting a pressurization system for a storable liquid.

The other concurrent session, chaired by Charles J. Marsel of New York Univ., heard papers on monopropellants. T. T. Sjoblom, Technical Research Associates, and P. J. Pizzalato, New York Univ., reviewed the problems of monopropellants. W. A. Cuddy of Wyandotte Chemical discussed some of the limitations and the desirability of uniform testing procedures related to JANAF methods of liquid propellant testing. The molecular structure of hydrazine and the catalysis of hydrazine decomposition on metal surfaces were covered in an interesting paper by I. J. Eberstein and I. Glassman of Princeton Univ. Papers on hydrazine were given by N. S. Davis Jr. of Rocketdyne and J. C. McCormick of Becco Chemical together with G. A. Voorhees Jr. and R. C. Ahlert of Rocketdyne.

Banquet guest of honor and speaker Roy Marquardt discussing "Propulsion Challenges of the Sixties." Seated at his left, Loren Bollinger, general chairman of the conference.

Karl E. Krill of Ohio State presented some problems of research and development at a university during a talk at the Monday luncheon, which was under the toastmastership of Alex Lemmon. The importance of a balance between teaching and research was emphasized together with the idea that a good teacher does research too.

D. A. Dooly of Space Technology Labs started his session on liquid rocket engine systems by having M. A. Cancilla of Rocketdyne present results of Thor qualification testing. One of the most interesting papers was that by C. A. Hauenstein of Rocketdyne on the experimental development of a tap-off rocket engine system. Unfortunately the preprint ran into classification problems, but it will be released later in revised form for those in-



At the Monday evening reception given by NAA's Columbus Div., some prominent attendees have a chat: Left to right: Loren E. Bollinger, Alexis W. Lemmon Jr., G. L. Von Eschen, George R. Gehrkens, and Roy Marquardt.

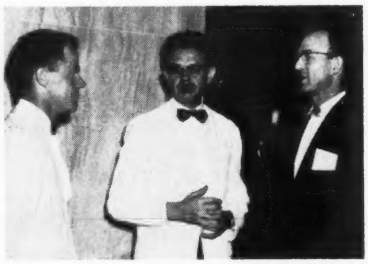
terested. A. L. Andrews talked on propellant utilization in the Thor.

The other afternoon session, under the direction of J. D. Mackenzie of General Electric, heard results of studies made by W. H. Bauer of Rensselaer Polytechnic Institute on the oxidation of boron hydrides. George Misko of Rocketdyne covered some spectroscopic techniques to obtain flame temperatures while S. F. Sarner of GE presented an integrated propellant performance analysis program. A review of ozone was presented by C. K. Hersh from Armour.

Attendees limbered up Monday night in the Deshler Hilton Hotel at a reception sponsored by North American Aviation, Columbus Div. At the banquet which followed, Roy Marquardt of Marquardt Corp. presented his ideas on the propulsion challenges during the 1960's. Very high Mach-number ramjets appear to be feasible, according to Marquardt. The toastmaster was L. E. Bollinger.

On the morning of July 19, E. L. Wilson of Douglas Aircraft initiated his session on the performance of liquid rocket engines by having J. A. Peterson of Tapco talk on the starting transients of hypergolic bipropellant rockets. His analytic approach was backed up by experimental studies in which the ambient pressure was as low as 1 mm of mercury. P. F. Massier and E. J. Roschke of JPL followed up with their results on experimental studies of supersonic exhaust diffusers for rocket engines. Best performance was obtained when injection or extraction of mass flow was used in conjunction with second-throat-type diffusers.

C. M. Beighley of Aerojet-General had a concurrent meeting on storable propellants. J. Jortner of Rocketdyne, J. A. Gibb, and J. A. Mellish together with D. M. Tenenbaum of Aerojet-General presented papers on the applicability, performance, and testing of various storables in three papers.



From left, James L. Harp, president of the ARS Columbus Section, Bertram Thomas, president of Battelle Memorial Institute, and Kenneth W. Greenlee, vice-president of the Columbus Section, pause thoughtfully during the reception.

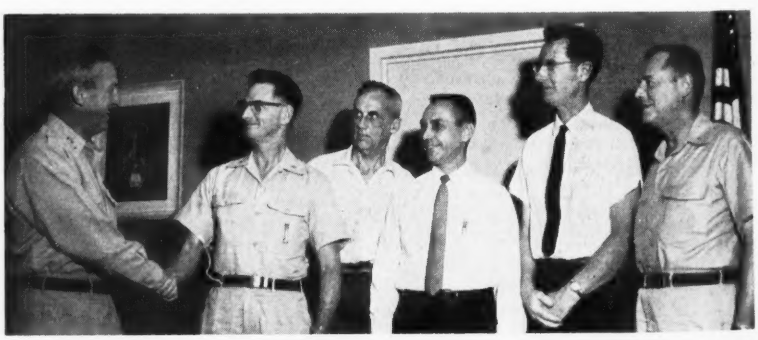
At lunch on Tuesday, Emerson W. Smith of NAA's Columbus Div. expounded on the subject, "Why is There a Space Problem?" Martin Goldsmith handled the job of toastmaster for this luncheon.

The engines and combustion session of the afternoon was chaired by Col. F. J. Seiler, director of science for the Air Research and Development Command. F. R. Hickson and M. W. Cardullo of the Naval Air Rocket Test Station discussed their studies of variable-thrust rocket engines. A new criterion to predict detonability was presented by E. S. Fishburne and R. Edse of Ohio State. Results were applied successfully to ozone and nitric oxide. Studies with ethanol drops in a rocket combustor burning ethanol and liquid oxygen were discussed by R. D. Ingebo of NASA Lewis Research Center. Other droplet-study results were given by D. W. Dykema and S. A. Greene of Rocketdyne.

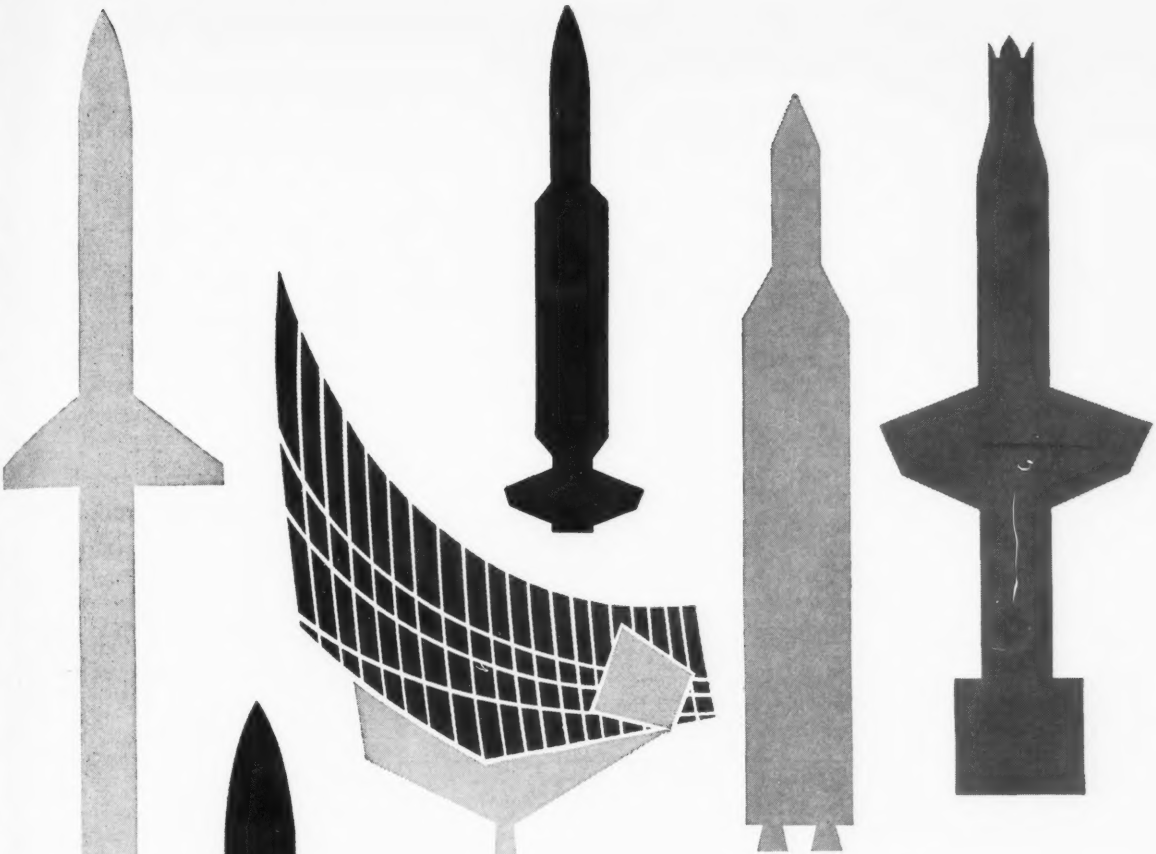
Howard P. Barfield of the AF Flight Test Center was chairman of the storable propellants session on Tuesday afternoon. Various ideas for storable hybrid systems were presented by F. J. Hendel of Aerojet-General while S. Tannenbaum of Reaction Motors considered the development of packaged liquids. J. A. Bottorff from Aerojet-General concluded the session with a talk on the experimental evaluation of new storables.

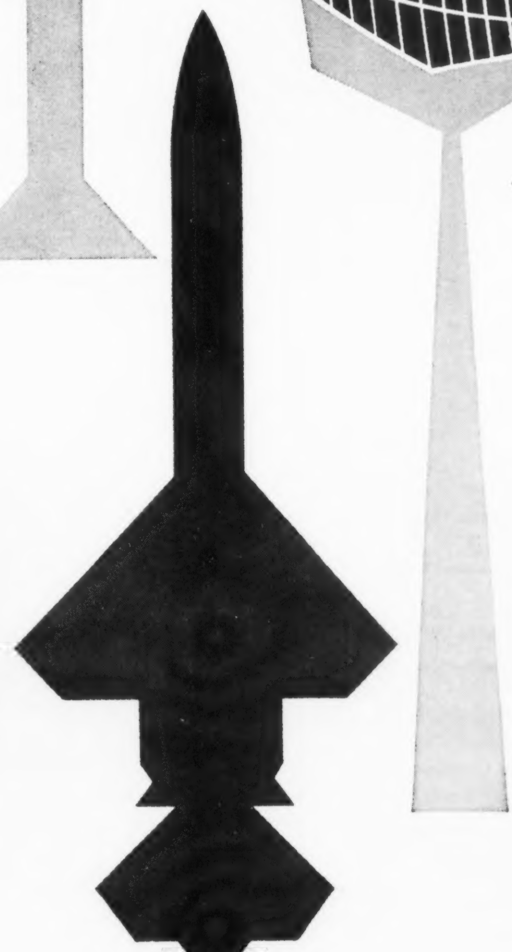
What appeared would be the most intriguing paper of the meeting—on the ultimate chemical propellant by Bridgforth, Carkeek, McLain, and Chase of Boeing—was withdrawn for security and proprietary reasons at practically the last instant. Several commenters were ready with prepared discussions.—**Loren E. Bollinger**

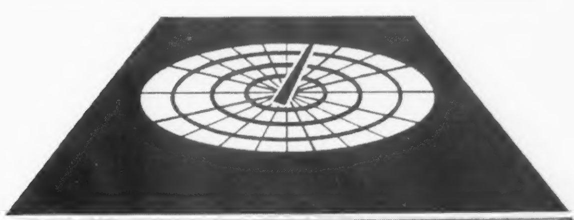
Memorable Anniversaries



On the 30th Anniversary of the American Rocket Society, Lt. Col. Prentice Peabody, Florida Section president, congratulates Maj. Gen. Leighton I. Davis, commander of AFMTC (far left), and Brig. Gen. William L. Rogers, vice-commander of AFMTC (far right), on the 10th Anniversary of Cape Canaveral. With Lt. Col. Peabody are Hugh C. Normile (third from left), treasurer, Edward J. Kizak, secretary, and Raymond V. Goddard, vice-president of the Section. General Davis is an ARS Fellow and Gen. Rogers is a member of the board of directors of the Florida Section.







ARS Receives $55,403 Grant from NSF to Continue Publication of ARS JOURNAL Russian Supplement

ARS has received a grant in the amount of $55,403 from the National Science Foundation in support of publication in *ARS Journal* of selected translations of Russian articles in the fields of rocketry and astronautics for an additional one-year period. The *Russian Supplement* to the *Journal* began publication on a quarterly basis last October under a previous NSF one-year grant, and will be published bi-monthly beginning this month.

During the first year of the program's operation, it became apparent that more material of importance was available than could be published within the bounds of a 200-page-per-year program. However, in order to keep the program as selective as possible, it was decided to increase the number of published pages by only 20 per cent. Thus the total number of pages to be published during the coming year is 240, compared with 200 last year. Approximately 40 pages will be published in the *Russian Supplement* every other month, as against approximately 50 pages on a quarterly basis during the past year.

In addition, the *Supplement* this year will include abstracts of important articles in the fields of rocketry, astronautics, and allied fields appearing in other journals now being translated into English under NSF-sponsored and privately funded cover-to-cover translation programs.

The present cover-to-cover Russian translation program encompasses over 75 journals, mostly monthlies. The average distribution of these English-language Russian periodicals is less than 500, and there is evidence that they are insufficiently read by American astronautical engineers and scientists. The barrier is poor distribution.

Translated articles of importance appearing elsewhere will thus be brought to the attention of astronautical scientists through the *ARS Journal Russian Supplement*. This will be accomplished by scanning translated journals systematically on a regular basis, selecting the 100 to 150 most significant papers in each two-month interval, and reprinting the abstracts and journal references in a special 16-page section of the *Supplement*.

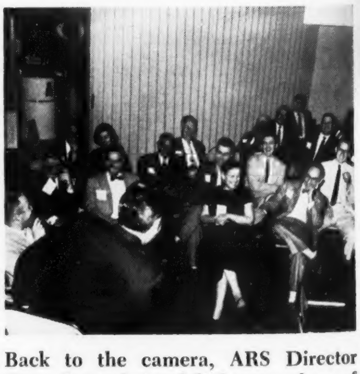
This program will not only provide the obvious service of bringing a large amount of information to those who need it and can use it, but, it is hoped, will stimulate sales of NSF-sponsored translated journals, which might eventually reduce the costs of these journals and thereby further stimulate the broad distribution of this information.

Propellant Thermodynamics Proceedings Now Available

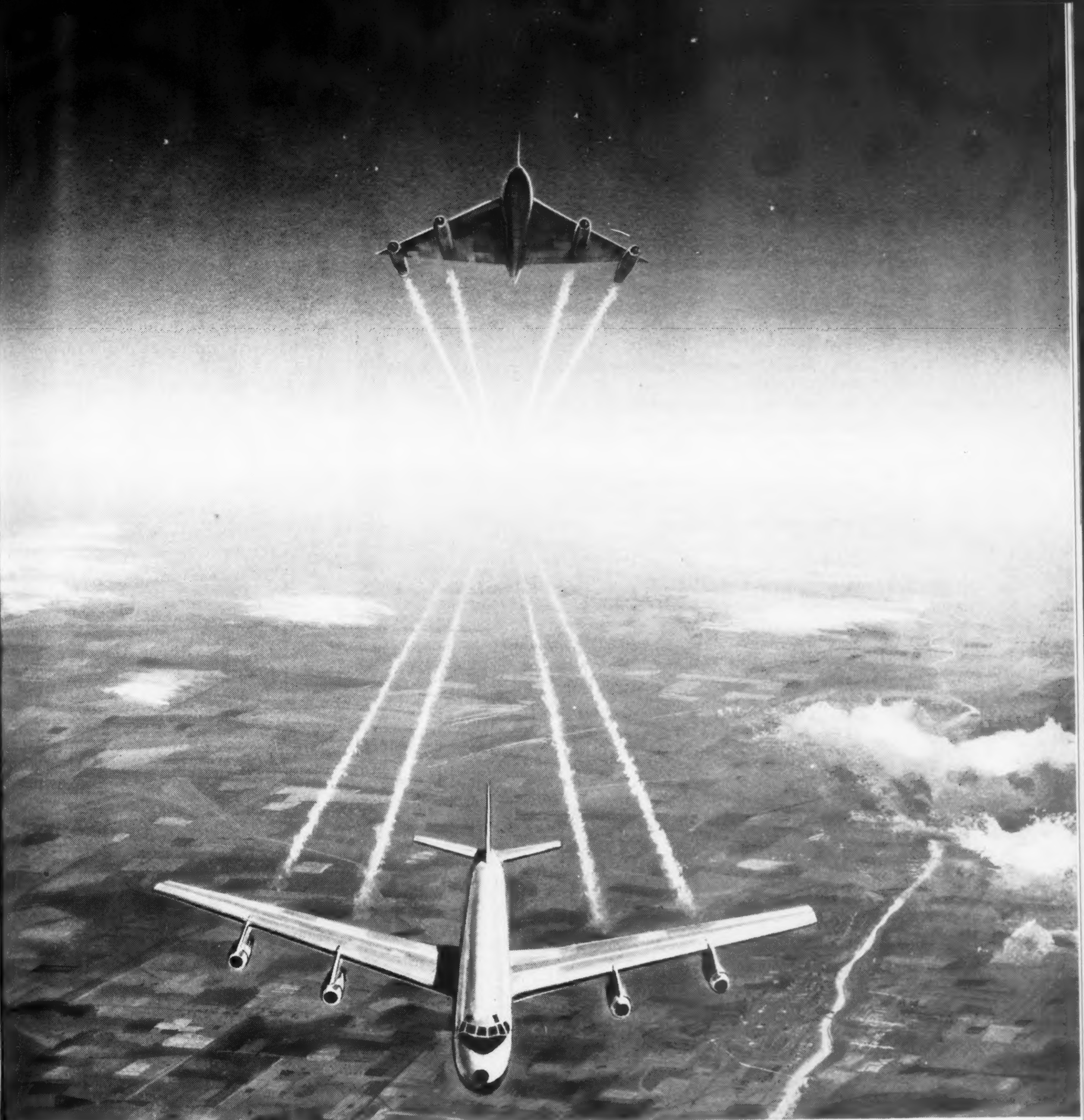
Proceedings of the ARS Propellant Thermodynamics and Handling Conference, held at Ohio State Univ., July 20–21, 1959, are now available from the university. Papers included in the proceedings cover such subjects as thermodynamic properties of propellants, handling of high-energy fuels, handling of fluorine, thermodynamics and combustion processes, rocket-performance-calculation techniques, combustion, propellant handling, and performance analysis and thermodynamics.

Copies of the proceedings, paperbound, are $4.00 each. Checks or money orders should be made payable to The Ohio State University and sent to: Publications Office, Ohio State Univ., Engineering Experiment Station, 156 West 19th Ave., Columbus 10, Ohio.

Tales of Von Karman



Back to the camera, ARS Director Tony Oppenheim delights members of the Chicago Section with anecdotes by and about "The Master," Theodore Von Karman, distinguished aerodynamicist and raconteur. Left foreground, with cigar, Chuck Miesse, the Chicago Section's enthusiastic and active president.



On the calendar

1960

Sept. 7–9	ISA, AIChE, AIEE, ASME, and IRE Joint Automatic Control Conference, MIT, Cambridge, Mass.
Sept. 19–21	1960 IRE National Symposium on Space Electronics and Telemetry, Shoreham Hotel, Washington, D.C.
Sept. 21–25	Air Force Assn. National Convention and Aerospace Panorama, San Francisco.
Sept. 26–30	3rd ISA Instrument-Automation Conference and Exhibit, N.Y. Coliseum, N.Y.C.
Sept. 27–30	**ARS Power Systems Conference, Miramar Hotel, Santa Monica, Calif.**
Oct. 4–6	IRE Conference on Radio Interference Reduction, Chicago, Ill.
Oct. 10–12	**ARS Anatomy of Manned Space Operations Conference, Biltmore Hotel, Dayton, Ohio.**
Oct. 12–14	AF Symposium on Astronautics, sponsored by AFOSR and Society of Automotive Engineers, Ambassador Hotel, Los Angeles.
Oct. 14–15	Symposium on Revolution in High-Speed Photography, Society of Photographic Scientists & Engineers, Washington, D.C.
Oct. 20–21	Hypervelocity Projection Techniques Conference, Univ. of Denver, Colorado.
Oct. 24–26	Medical and Biological Aspects of the Energies of Space Symposium, sponsored by USAF Aerospace Medical Center (ATC), Granada Hotel, San Antonio, Tex.
Oct. 26–27	1960 Computer Applications Symposium sponsored by Armour Research Foundation, Morrison Hotel, Chicago.
Oct. 27–28	IRE Professional Group on Electron Devices Meeting, Shoreham Hotel, Washington, D.C.
Nov. 3–4	**ARS and U.S. Naval Postgraduate School Conference on Electrostatic Propulsion, Monterey Calif.**
Nov. 15–16	Symposium on Engineering Application of Probability and Random Function Theory, Purdue Univ., Lafayette, Ind.
Nov. 15–17	AF-Navy-Industry Propulsion Systems Lubricants Conference, sponsored by ARDC & Southwest Research Institute, Granada Hotel, San Antonio, Tex.
Nov. 21–26	Colloquium on Space Research sponsored by Argentine National Committee for Space Research and Argentine Interplanetary Society, Buenos Aires, Argentina.
Dec. 5–8	**ARS Annual Meeting and Astronautical Exposition, Shoreham Hotel, Washington, D.C.**
Dec. 13–15	Annual Eastern Joint Computer Conference, Hotel New Yorker and Manhattan Center, New York, N.Y.

1961

Feb. 1–3	**ARS Solid Propellant Rocket Conference, Hotel Utah, Salt Lake City, Utah.**
Feb. 1–3	IRE Winter Military Electronics Convention, Biltmore Hotel, Los Angeles.
March 13–16	**ARS Testing Conference, Biltmore Hotel, Los Angeles.**
April 5–7	**ARS Conference on Lifting Re-entry Vehicles: Structures, Materials, and Design, El Mirador Hotel, Palm Springs, Calif.**
April 18–20	Symposium on Chemical Reaction in Lower and Upper Atmospheres, sponsored by Stanford Research Institute, Mark Hopkins Hotel, San Francisco.
April 26–28	**ARS Detonation and Deflagration Phenomena Conference, Palm Beach Biltmore, Palm Beach, Fla.**
May 22–24	**ARS National Telemetering Conference, Chicago, Illinois.**
June 7–9	**ARS Semi-Annual Meeting, Statler-Hilton Hotel, Los Angeles.**
Aug. 21–23	**ARS International Hypersonics Conference, MIT, Cambridge, Mass.**
Aug. 23–25	**ARS Biennial Gas Dynamics Symposium, Northwestern Univ., Evanston, Ill.**
Oct. 9–13	**ARS SPACE FLIGHT REPORT TO THE NATION, New York Coliseum, New York, N.Y.**

SECTION NEWS

Alabama: NASA's Director of Space Flight Programs, **Abe Silverstein,** spoke to an audience of approximately 200 members of the Section in July on "Missions and Payloads of NASA Projects." Dr. Silverstein outlined the fundamental studies being conducted by the space agency in search of a better understanding of the influence of the sun on the behavior of the earth, the origin of the solar system, and life beyond the planet earth. Payload schemes to accomplish these missions were discussed in concept.

Joining with the Section in co-sponsoring this special meeting were the Huntsville chapters of the IRE, ASME, and Astronomical Association.

Robert A. Schmidt, chairman of the ARS Technical Committee on Test Facilities and Support Equipment, was introduced as an out-of-town guest.

Two members of the Alabama Section received special recognition by the Dept. of the Army in a ceremony conducted at Redstone Arsenal on July 14. Maj. Gen. August A. Schomburg presented the Army's highest civilian award to **Arthur Rudolph** and to **Konrad K. Dannenberg.**

The citation of Dr. Rudolph was made for his outstanding contribution to the Army while serving as project director for development of the Redstone and Pershing missiles. Dr. Rudolph is now head of the newly formed Research and Development Directorate of ABMA. The citation of Mr. Dannenberg was made for his meritorious service as project director for Jupiter. Mr. Dannenberg is presently a member of the Saturn Project of the newly created George C. Marshall Space Flight Center located at Redstone Arsenal.

—**James B. Bramlet**

Antelope Valley: At a meeting in June, the following members were elected officers for the coming year: Philip Fahey, president; Hubert Drake, vice-president; Lt. Walter A. Schaal, USAF, secretary; and C. Johnson, treasurer.

—**Walter A. Schaal**

Chicago: The Exhibition Hall of the Borg-Warner Building was the scene of an informal June meeting which featured ARS Director **Tony Oppenheim's** tales of Von Karman, and a report from the local board. Approximately 50 members and prospects enjoyed the hospitality of the Industrial Sponsors, exchanged "Todor" anecdotes with the speaker, and engaged in spirited debate on AMERICAN ROCKET SOCIETY policy. Under heavy fire for the

Society's firm stand against amateur firings, the agile Professor Oppenheim deftly fielded each question and suggested to one of the amateur rocketeers in attendance that he seek assistance from the Rocket Lab of Purdue Univ. Thanks to this recommendation, plans have been made for a safe supervised firing in the near future.

Further midsummer activities included a "Keynote Address" by Section president **C. C. Miesse** to some 400 teachers assembled at Iowa Wesleyan College for the Air-Age Workshop, July 18 and 19. Title of the illustrated presentation of propulsion principles and space flight requirements was "The Marriage of Missiles and Missions."

—C. C. Miesse

Dayton: The following members have been elected officers for the year: A. G. Liefke, Cook Electric, president; Col. Harvey P. Huglin, WADC, vice-president; Allan U. Macartney, Westinghouse Electric, secretary; Darrell L. Schneider, Beech Aircraft, treasurer.

—A. G. Liefke

Holloman: The Section held a dinner meeting in the picturesque Cloudcroft Lodge at Cloudcroft, N.M., in late June. President Harold Von Beckh minimized preliminary formalities and introduced a panel of distinguished scientists gathered with the Holloman Section to lead a discussion on "Science in the World Today": **Geoffrey I. Taylor,** Yarrow Research Professor Emeritus of the Royal Society, from England; **John Bardeen,** Nobel laureate and professor of physics at the Univ. of Illinois; **H. P. Robertson,** professor of mathematical physics at the California Institute of Technology; and **William A. Fowler,** professor of theoretical physics at Cal Tech.

Knox Millsaps, chief scientist for the AF Missile Development Center, was moderator. He first called on Dr. Fowler to give his views on the prime question of the evening in view of his recent trip to Russia. The principal element mentioned by Dr. Fowler was the relative scholastic system. For example, he said he thinks students in Russia leaving high school are far better prepared to enter college than those in this country. Further, the intensity of training is much greater in Russia. The average Russian student takes approximately 36 hours of course work versus 20 hours in a university in this country. The key point, however, is that the Russian student has no electives.

Dr. Robertson next added comments concerning science in foreign and national affairs. He pointed out that the

1960–61 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
Sept. 27–30	Power Systems Conference	Santa Monica, Calif.	Past
Oct. 10–12	Anatomy of Manned Space Operations Conference	Dayton, Ohio	Past
Nov. 3–4	Electrostatic Propulsion Conference	Monterey, Calif.	Past
Dec. 5–8	ARS Annual Meeting and Astronautical Exposition	Washington, D.C.	Past
1961			
Feb. 1–3	Solid Propellant Rocket Conference	Salt Lake City, Utah	Sept. 30
March 13–16	Testing Conference	Los Angeles, Calif.	Oct. 17
April 5–7	Lifting Re-entry Vehicles: Structures, Materials, and Design Conference	Palm Springs, Calif.	Oct. 31
April 26–28	Detonation and Deflagration Phenomena Conference	Palm Beach, Fla.	Nov. 28
May 22–24	National Telemetering Conference	Chicago, Ill.	Jan. 16
June 7–9	ARS Semi-Annual Meeting	Los Angeles, Calif.	Feb. 1
Aug. 21–23	International Hypersonics Conference	Cambridge, Mass.	
Aug. 23–25	Biennial Gas Dynamics Symposium	Evanston, Ill.	
Oct. 9–13	ARS SPACE FLIGHT REPORT TO THE NATION	New York, N.Y.	May 2

Send all abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

danger we must avoid is the mixing of political and scientific adherence. In Russia, the scientific community is directed at an intensive rate on specific problems; consequently, they have an appreciable capability in specific areas. The thing we must avoid in a democracy is allowing this, which is a political control of scientific endeavor, to predominate. We must always allow and foster nondirected science.

Sir Geoffrey aimed his comments at a defense of the English system of education and instruction as compared with others. They too have an intensive system in that an engineer may be graduated in three years instead of the current rate in this country of about 5 years.

Dr. Bardeen discussed the comparative quality of the systems in Russia and in this country. He too commented on the directed and therefore limited educational and research system versus the free educational and research system in a democracy. He chose for an example the semiconductor as an item which in specific use in given Russian products had made remarkable progress. However, in terms of the general realization and applications of semiconductors, this country is far ahead

The entire evening's discussion was stimulated by questions from the floor. Another distinguished scientist, **Fritz Zwicky**, of CalTech, suggested that the scientific community was obligated to devote time to other than the more sophisticated problem areas. His point was that the simple things of life need intensive scientific study if we are to cope with advancing civilization. He chose as an example the smog in Los Angeles.

All in all, it was an interesting and informative discussion. Participation of these outstanding men of science lent it depth and deeply engaged the audience.

—**Harry H. Clayton**

Maryland: The following members have been elected officers for the coming year: Howard C. Filbert, Miller Research Labs, president; Ralph P. Gray, Westinghouse Electric, vice-president; Walter D. Smith, Martin, secretary; and Joseph E. Montalbano, Aircraft Armaments, treasurer.

—**R. P. Gray**

Sacramento: The April general meeting of the Section, held at the McClellan AFB Officers Club, featured as speaker **Robert Tripp,** executive assistant to the vice-president of Aerojet-General's Liquid Rocket Plant, whose topic was "Adventures in Rocketry," based on the television show of the same name. After explaining for the ladies what their husbands do about rockets at work, Tripp discussed briefly the present emphasis on getting into space. Drawings by Robert Truax for building large rockets at shipyards and firing them at sea were displayed.

The May general meeting drew more than 100 members and guests. Guest speaker **R. Heikes,** manager of the Westinghouse Solid State Electronics Laboratory in Pittsburgh, discussed "Current Developments in Thermoelectricity." Dr. Heikes reviewed the background to today's applied research in this important area of science and engineering, especially on key materials. He also briefly discussed Russian efforts in this field, noting that he felt that the United States is ahead.

At our June meeting, **Kenneth Errington** spoke on "Rocket Development in the United Kingdom." Dr. Errington is the British defense establishment's assistant director of guided missiles, propulsion, and warheads, with responsibilities for headquarters coordination of requirements for propulsion and warheads in guided weapons and for safety of guided weapons.

Our July speaker was **William C. House,** director of nuclear rocket operations for Aerojet-General, who spoke on "Space Development in the Next Ten Years/The Potential of Military Operations in Space."

No meeting took place in August, but a very interesting one is on tap for September. **Kurt R. Stehling,** scientist for rocket propulsion in the NASA Office of Program Planning and Evaluation, will talk on "Lunar Propulsion Problems."

Scheduled for October is **B. D. Cul-**

ver, director of the Space Medical Laboratory, Space Technology Div., Aerojet-General, who will discuss the status of space medicine.

M. J. Zucrow is scheduled to speak later this year, although a firm date has not been set.

—Max Halebsky and J. J. Sogorka Jr.

Southern California: In June, the Section sponsored a panel discussion on "The U.S. Space Program—Results to Date," led by **William H. Pickering** of JPL. The other participants in the discussion were **Albert R. Hibbs** of JPL, **William W. Kellogg** of Rand Corp., **George E. Mueller** of STL, and **E. Harry Vestine** of Rand. The meeting, held in the IAS Auditorium, was open to the public.

—George E. Pelletier

Southern Ohio: The following members have been elected officers for the 1960–61 period: D. E. Robison, GE, president; Ernst A. Steinhoff, Avco Mfg., vice-president; Stanley F. Sarner, GE, treasurer; and Guntis Kuskevics, GE, secretary.

—D. E. Robison

Twin Cities: Officers for the fiscal year July 1960–61 will be as follows: T. E. Murphy, Univ. of Minnesota, president; H.O. Raabe, General Mills, vice-president; D. Lowrey, 3M, secretary; and Charles Scott, Rosemount Aeronautical Labs, treasurer.

—Rudolf Hermann

Wichita: The spring dinner meeting of the Wichita Section was held at the Boeing employees' cafeteria. In spite of the "Confidential" clearance required, there were 185 members and guests in attendance. Section President Hal Roberts called the meeting to order. Program Chairman Larry McMurtrey introduced the guest speaker, **Ben Hamlin** of Boeing-Seattle, manager of the Dynasoar military test system in the Dynasoar program manager's office. Hamlin gave a very informative and interesting presentation of the Dynasoar program, illustrating his talk with slides. Covering the present vehicle configuration, he stated that precautions being taken with regard to the pilot's safety are expected to give the Dynasoar pilot about the same chance of survival as a pilot currently flying a Century-series fighter. He emphasized that no engineering breakthroughs are required to make Dynasoar a reality. However, the last slide listed the number of government organizations which are contributing toward the Dynasoar project, indicating that some "breakthrough" in government regulation may be necessary.

—Roger J. Nyenhuis

Florida Activities

Henry W. Phillips, left, manager of BMEWS, guest speaker before the Joint Technical Council membership at Patrick AFB, chats with Lt. Col. Prentice Peabody, USAF, president of the ARS Florida Section (center), and Capt. Douglas Egan, USAF, Avco Nose Cone Officer, right.

STUDENT CHAPTERS

Parks College: At a regular meeting in July, the Chapter elected the follow-

ing officers for the term from September 1960 to April 1961: Jose E. Velez, president; Emil Pyk, vice-president; Everett Pittman, secretary; John E. Owen, treasurer; and Martin Pearce, librarian.

Immediately preceding the elections, **Jerome Vetter,** a senior here at Parks, gave a highly enlightening talk on "Selected Perturbation Effects on Elliptical Earth Satellites for Use in Photographic Missions," his thesis.

Present at the meeting was **William Felding,** president of the St. Louis Chapter of the AMERICAN ROCKET SOCIETY.

—Everett Pittman

CORPORATE MEMBERS

Air Products, Inc., has unveiled a new $6,000,000 liquid oxygen plant at Creighton, Pa., that can produce 200 tons/day of lox and liquid nitrogen plus argon . . . **Atlantic Research Corp.** has broken ground at its headquarters site for a 120,000-sq ft building to house Jansky & Bailey, Inc., and Desomatic Corp., ARC affiliates . . . **Bendix Corp.** has acquired a controlling interest in Disenadores y Constructores, S.A. (Dicosa), a leading Mexican tool and die firm . . . **Collins Radio** has announced plans for construction of a 38,000-sq ft two-story communication and data processing center in northeast Cedar Rapids, Iowa.

Convair Div. of **General Dynamics Corp.** has let contracts for design and construction of a space radiation research facility in San Diego, Calif., to study radiation effects on electronic components, guidance and control systems for nuclear-propelled vehicles. An improved 3,000,000-volt electron/ion accelerator will be used as the source of radiation. The division is also currently building a million-dollar electronics manufacturing facility . . . **Hughes Aircraft** has changed the name of its Airborne Systems Group to Aerospace Group . . . **IBM's** subsidiary The Service Bureau Corp. has set up a computer program service to determine rocket and missile fuel requirements . . . **Linde Co.** has formed a Cryogenic Products Dept., responsible for engineering, designing, and manufacturing new cryogenic equipment . . . **Litton Industries** has organized Litton Systems, Inc., a wholly-owned subsidiary, to handle its expanding defense equipment and systems activities . . . **Lockheed** has dedicated an ultramodern $155,000 avionics laboratory at its Marietta, Ga., plant . . . **Martin Co.** has acquired a substantial stock interest in Nuclear Corp. of America.

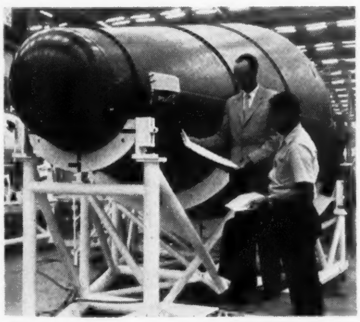
Lamtex Industries, Inc. Becomes Corporate Member

Lamtex Industries, Inc., Farmingdale, N.Y., has joined the AMERICAN ROCKET SOCIETY roll of corporate members participating in ARS activities. The firm produces reinforced plastics and specializes in filament wound pressure vessels, rocket motors, and related items. Named to represent Lamtex are Warren E. Ponemon, president; Jonas Medney, executive vice-president; Hsing Liu, vice-president; Myron Segal, sales engineer; and Charles Kurz, senior project engineer.

Polaris End-Closures Explosively Formed

These explosively formed Polaris-motor end closures—with a uniform wall thickness of 0.40 ± 0.002 in.—are now turned out by Aerojet-General's Ordnance Div. on a production basis. The explosive-forming process utilizes an Aerojet-developed liquid explosive called Aerex.

Centaur Nose Cone—Glass Fiber Deluxe



Convair–Fort Worth engineers check out the first nose cone for the Centaur space vehicle before shipping it to Convair (Astronautics) in San Diego, Calif. Convair believes the nose cone—10 ft in diam across the base and 18 ft high—is the largest structure ever made entirely of glass-fiber sandwich.

Sunflower I Collector

The young lady shows the scale of the solar collector for Sunflower I, the 3-kw auxiliary power system being developed by TRW's Tapco Group for NASA under a recently awarded contract expected to run three years in a $4.9 million program. Sunflower I will have an operating time of about a year, and will be used with vehicles launched by Saturn and Centaur rockets.

Model Moon

Raymond Benton shows a model (scale of 1 in. to 100 miles) of the moon that he has created as a teaching aid. The model follows the Carnegie moon globes and other authoritative sources, and has been prepared to avoid limb distortion. It is cast of plastic and hand-painted—maria in grays and rays in white.

Design notes

Polaroid-Land Film Type 57 for Moon Photography

By Hector C. Ingrao and Ingemar Furenlid

HARVARD COLLEGE OBSERVATORY, CAMBRIDGE, MASS.

Many problems in observational astronomy could be solved or simplified by means of a photographic technique that uses high-speed photographic emulsion. For general use, and specifically for astronomical photography, the data on the speed of the emulsion alone does not mean too much unless we know the reciprocity failure, graininess, resolving power, fog level, spectral response, etc.

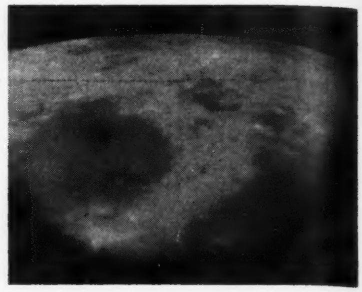
At the suggestion of Prof. Donald H. Menzel, with the cooperation of the Polaroid Co., Cambridge, Mass., we decided to investigate the Polaroid-Land Film Type 57 for possible space use.

As a preliminary test, we used the film to photograph the moon, with the 15-in. Mertz (visual) refractor at Harvard College Observatory. The refractor has a focal length of 269 in.; as enlarging lens we used a Switar objective of 1-in. focal length ($f/1.5$). Our camera was made from an old Speed Graphic with an adapter for the Polaroid Land 4 x 5 film holder. The effective focal ratio of the optical system was $f/90$. No correcting filter was used for the first pictures.

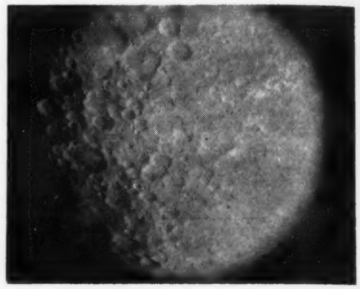
After several trials, we found the right focus and range of exposure time. This range turned out to be from $^1/_{10}$ sec up to $^1/_{125}$ sec, depending on the brightness of the area photographed, zenithal distance and age of the moon, and atmospheric extinction. This rather short exposure time allowed us to evaluate the seeing of the atmosphere through the finder and to trigger the camera at the time of best seeing. Unfortunately, the seeing during the time we took the pictures was poor, as it usually is in Cambridge.

For developing the film, we used the regular Polaroid-Land photographic process, which gives a positive picture immediately after developing. The developing time we used ranged from 2 to 4 min, according to the film temperature.

Although it is still too early for us to evaluate this film completely for particular astronomical applications, we believe that these pictures of the moon give some idea of what may be expected from this film for planetary photography.



An exposure time of $^1/_{40}$ sec, taken at 6^h52^m p.m. EST, January 8. At the bottom right is the Mare Crisium, and the top right part of the Mare Foecunditatis.



An exposure time of $^1/_{10}$ sec, taken at 8^h20^m p.m. EST, January 7. Tycho appears at the left, slightly above center, and below it, little to right, Maginus.

Surface for Control of a Re-entry Vehicle

By Richard V. Warden, Senior Engineer

AERONUTRONIC, DIV. OF FORD MOTOR CO., NEWPORT BEACH, CALIF.

Some of the body shapes considered for re-entry vehicles show instability at high angles of attack. This problem is usually avoided by requiring the guidance system to control the angle of attack within certain limits. However, guidance may become inoperable by the time of separation, or adverse tip-off velocities may occur to induce a large angle of attack at the time of re-entry.

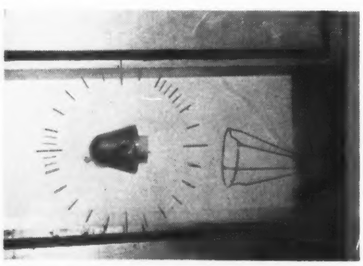
The configuration developed for the Hyper-Environment Test System 609A Data Recovery Vehicle shows particular promise. Use has been made of an aerodynamic cruciform fin with the following features:

(1) Fins mounted on vehicle base symmetrical with its longitudinal axis, as shown in the photo here.

(2) Fin span less than the base diameter (to protect them from severe aerodynamic heating).

(3) Fin surfaces capable of carrying loads imposed early in re-entry.

When the vehicle is initially at an undesirably high angle of attack, these fins are capable of producing a large restoring moment on the vehicle. With movable fins, guidance control may be effected by deflecting one or more surfaces. However, this feature has not been explored during the present HETS project.



Model VIII Mounted in Test Section

Wind-tunnel tests were performed at the UCLA supersonic tunnel with several base configurations. The tunnel capability, $M = 2.87$, did not permit simulating the initial re-entry regime, so only a comparative analysis of the stability range of the models was possible.

The models utilized a single forebody with three interchangeable bases—flat base, sphere-segment base with annular groove, and cruciform fin base. The latter was so designed as to permit the testing of four fine sizes, as listed in the table.

The models were suspended at their CG's on a wire which ran transversely across the center of the test section. This permitted freedom to pitch 360 deg. The models were balanced about their pivot holes for each configuration by adjusting a threaded weight inside the model.

The flat base was unstable past approximately α (angle of attack, nose up positive) $= \pm 140$ deg. The round base was dynamically unstable but statically stable backwards at $\alpha = 180$ deg. The fins increased the forward stability range from ± 145 deg with the smallest set to a full 360 deg of stablity with the largest set, as shown in the table. A film history also showed the fins increased damping.

In an attempt to determine the effect of the annular groove in the sphere-segment base, a number of runs were made with the groove filled with wax. The groove appeared to increase the apparent dynamic instability at $\alpha = 180$ deg. This instability caused a continuous oscillation through a limit cycle of approximately ± 12 deg at $\alpha = 180$ deg. Filling the groove with wax decreased the oscillations several degrees. At no time were the oscillations of sufficient amplitude to right the body.

Results of this test show good correlation with those from a modified Newtonian flow program for Models I, III, and VIII described in the table. This program is presumed to be valid down to Mach numbers of 2–3, providing the hypersonic similarity parameter (Mach number times local slope) is slightly greater than unity.

Test Configurations and Results

$C_{N\infty}$ = Normal force coefficient/radian; c = fin chord, in.; d = fin diam, in.

Configuration	% c.g.	$C_{N\alpha}$/Rad.	α Stable	Comments
I Flat Base	40.75 36.0	0.925 (1.08)*	$\pm 140^\circ$ $\pm 138^\circ$	Very stable backwards.
II Sphere Base with annular groove	40.75 36.00	1.33	$\pm 157^\circ$ $\pm 157^\circ$	Continuous oscillations about $\alpha = 180^\circ$
III Sphere Base groove filled in	36.00	(1.23)*	$\pm 167^\circ$	Continuous oscillations about $\alpha = 180^\circ$
IV Fin Base c = .2, d = .3	40.75 36.00	1.41	$\pm 149^\circ$ ± 143	Fins aligned to present least area to the flow for models IV, V, VI & VII. Fins rotated 45° about vehicle axis for VIII.
V Fin Base c = .3, d = .3	40.75 36.00	1.58	$\pm 155^\circ$ $\pm 143^\circ$	
VI Fin Base c = .3, d = .45	40.75 36.00	1.68	$\pm 166^\circ$ $\pm 149^\circ$	
VII Fin Base c = .3, d = .6	40.75	1.81	$0\text{-}360^\circ$	Would not remain at $\alpha = 180^\circ$.
VIII Fin Base c = .3, d = .6	40.75	1.81	$0\text{-}360^\circ$	Would not remain at $\alpha = 180^\circ$.

* Theoretical modified Newtonian.

People in the news

APPOINTMENTS

ARS National President **Howard S. Seifert** has been appointed chairman of the Stanford Univ. Interdepartmental Committee on Space Technology. Purpose is to coordinate pedogogic and research activities in space technology among the university departments.

Erich W. Neubert has been named associate deputy director for R&D at NASA's Marshall Space Flight Center. **Dieter Grau** succeeds Neubert as head of the center's Systems Analysis and Reliability Div. **William E. Guilian** becomes Marshall Center's general counsel; **John H. Warden,** patent counsel.

Maj. Gen. Thomas P. Gerrity has been appointed chief of AMC's Ballistic Missiles Center, Inglewood, Calif., and **Maj. Gen. W. A. Davis,** commander of AMC's Aeronautical Systems Center at Wright-Patterson AFB. **Brig. Gen. Robert G. Ruegg** replaces Gen. Davis as director of procurement and production at AMC headquarters.

Lt. Col. Glenn Crane has been named project officer in charge of the Army's Nike-Zeus program.

Bernhard H. Goethert, director of engineering for ARO, Inc., has been tendered a three-year appointment to the Fluid Dynamics Panel on AGARD.

Robert C. Elderfield, professor of chemistry at Univ. of Michigan, has been appointed chairman of the NAS-NRC's Div. of Chemistry and Chemical Technology. **Robert W. Cairns,** director of research, Hercules Powder Co. has been named chairman-designate.

W. E. Giberson has been promoted to chief of JPL's new Guidance and Control Div. at CalTech. Supporting Giberson will be **Howard H. Haglund,** deputy chief; **Henry A. Curtis,** chief, electronic devices section; **Garth E. Sweetnam,** chief, spacecraft secondary power section; **Norri Sirri,** chief, guidance and control systems section; **John R. Scull,** chief, electromechanical devices section; and **John H. Laub,** chief, guidance and control research section.

C. D. J. Generales Jr. has been appointed assistant professor of space medicine at the New York Medical College, where the subject has been made a part of the curriculum for students. Dr. Generales was also instrumental in the formation of a Space Medicine Section in the N.Y. State Medical Society.

Arthur Clayton Menius Jr. has been appointed dean of the new School of Physical Sciences and Applied Mathematics, a combining of the Departments of Chemistry, Experimental Statistics, Mathematics, and Physics, at North Carolina State College. **Raymond L. Murray,** Burlington professor of physics, succeeds Dr. Menius as head of the Dept. of Physics.

Charles J. Kensler, formerly professor and chairman of the Dept. of Pharmacology and Experimental Therapeutics at Boston Univ.'s School of Medicine, has been named vice-president in charge of Arthur D. Little, Inc.'s new Life Sciences Div.

Richard E. Horner has resigned as NASA associate administrator to become senior vice-president in charge of technological matters at Northrop Corp.

A. M. Johnston has been upped from chief of flight test, Boeing Airplane, to assistant Boeing program manager for Dynasoar.

Sperry Rand Corp. has selected **James W. Moyer** as research director of its new research center, to be built later this year in Sudbury, Mass. Dr. Moyer has served as a consultant to the National Bureau of Standards' Free Radicals Research Project and has worked with GE in planning and research posts.

E. Clinton Towl, one of the founders of Grumman Aircraft Engineering Corp. and administrative vice-president, has been named president of the company. Former senior vice-president **William T. Schwendler** has been chosen as chairman of the executive committee and **Llewellyn J. Evans,** former general counsel, to be a vice-president.

Frank P. DeLuca Jr. has been elected president of Acoustica Associates, Inc. He formerly served as executive vice-president of the ultrasonics firm.

A. J. Kullas, manager of technical development, has been named engineering director for The Martin Co.'s rocket booster portion of the AF's Dynasoar program. **Holmes M. Brown** becomes director of Martin communications.

S. N. Bean becomes manufacturing manager of the Polaris missile system program at Lockheed's Missiles and Space Div. **John W. Suurballe** has joined Lockheed Electronics Co.'s Systems Research Center, a subsidiary.

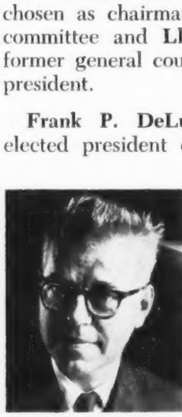
B. F. Coffman has been named manager, hybrid rocket engine projects, at Aerojet-General Corp.

Frederick W. Wendt has been appointed manager, space structures operation, in the Space Sciences Lab of GE's Missile and Space Vehicle Dept.

In the ground systems group at Hughes Aircraft Co., **A. Victor Stern** has been named manager of the new systems lab and **John F. Gardner,** plant engineer; **Lyle A. Jakees** and **James C. Evans** have been named senior scientists in the group's new systems lab.

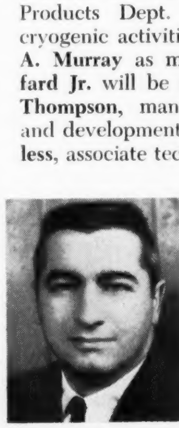
Heading up new research activities at Aeronutronic Div. of Ford Motor Co. are **Sol W. Weller,** chemistry and materials; **Leon Green Jr.,** propulsion; **George P. Carver,** experimental equipment; **Stewart I. Schlesinger,** mathematics and computing; **Arthur J. Ruhlig,** physics; **Cravens L. Wanlass,** physical electronics and bionics; and **William L. Vandal,** environmental test.

Linde Co. has formed a Cryogenic Products Dept. responsible for all cryogenic activities and named **Glenn A. Murray** as manager. **P. P. Huffard Jr.** will be sales manager; **R. L. Thompson,** manager of engineering and development; and **E. L. McCandless,** associate technical director. ♦♦



Kensler

Towl



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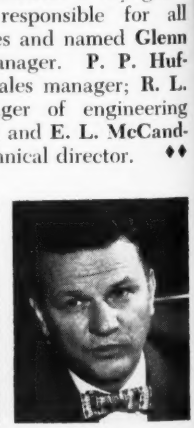


Kullas

Reflectors for Solar Power

Some 7000 of these small aluminum reflectors would be banked to focus solar rays on a thermocouple in a 1500-watt power generator under study by Hamilton Standard Div. of United Aircraft for WADD. The company will have a 100-watt model using about 900 reflectors ready for evaluation this fall. The banks of reflectors will be designed to unfold in space from a compact package.

Cyborgs and Space

(CONTINUED FROM PAGE 27)

continuous slow injections of biochemically active substances at a biological rate. The capsule is incorporated into the organism and allows administration of a selected drug at a particular organ and at a continuous variable rate, without any attention on the part of the organism.

Capsules are already available which will deliver as little as 0.01 ml/day for 200 days, and there is no reason why this time could not be extended considerably. The apparatus has already been used on rabbits and rats, and for continuous heparin injection in man. No untoward general effect on health was noted when the injector was buried in animals. As long as five years ago, an injector 7 cm long and 1.4 cm in diam, weighing 15 gm, was successfully buried under the skin of rats weighing 150–250 gm. The photo on page 27 shows a rat weighing 220 gm with an injector *in situ*.

The combination of an osmotic pressure pump capsule with sensing and controlling mechanisms can form a continuous control loop which will act as an adjunct to the body's own autonomous controls. In this manner, these controls can be changed to the desired performance characteristics under various environmental conditions. If these characteristics were determined, such a system would be possible today with the selection of appropriate drugs.

For example, systolic blood pressure may be sensed, compared to a reference value based on the space conditions encountered, and regulated by letting the difference between sensed and reference pressures control administration of an adrenergic or vasodilator drug. Of course, any such system presupposes that we would be cognizant of what optimum blood pressure would be under various space conditions.

While it is quite difficult to set up per limits to "natural" human physiological and psychological performance, we can take as minimal the capabilities demonstrated under control conditions such as yoga or hypnosis. The imagination is stretched by the muscular control of which even the undergraduate at a Yoga College is capable, and hypnosis per se may prove to have a definite place in space travel, although there is much to be learned about the phenomena of dissociation, generalization of instructions, and abdication of executive control.

We are now working on a new preparation which may greatly enhance hypnotizability, so that pharmacological and hypnotic approaches may be symbiotically combined.

Psycho-Physiological Problems

Let us now turn our attention to some of the special physiological and psychological problems involved in space travel, and see how Cyborg dynamics may help achieve better understanding and utilization of man's natural abilities.

Wakefulness. For flights of relatively short or moderate duration—a few weeks or even a few months—it would appear desirable to keep the astronaut continuously awake and fully alert. The extension of normal functioning through the use of that group of drugs known as psychic energizers, with adjunctive medication, for this purpose is a present-day reality. In flights lasting a month or two, no more than a few hours a day of sleep would be required in the normal environment if such drugs were employed. Tests indicate efficiency tends to increase, rather than decrease, under such a regime, and extended usage appears entirely feasible.

Radiation Effects. One subsystem of the Cyborg would involve a sensor to detect radiation levels and an adaptation of the Rose osmotic pump which would automatically inject protective pharmaceuticals in appropriate doses. Experiments at the AF School of Aviation Medicine already indicate an increase in radiation resistance resulting from combined administration of aminoethylisothioronium and cysteine to monkeys.

Metabolic Problems and Hypothermic Controls. In the case of prolonged space flight, the estimated consumption of 10 lb a day for human fuel—2 lb of oxygen, 4 lb of fluid, and 4 lb of food—poses a major problem. During a flight of a year or longer, assuming that the vehicle was operating satisfactorily, there would be little or no reason for the astronaut to be awake for long periods unless some emergency arose. Hypothermia (reduction of body temperature) would appear to be a desirable state in such long voyages in order to reduce metabolism, and thus human "fuel" consumption. The use of external cooling, reduction of the temperature of the blood in an arterio-venous shunt, and hibernation (through pituitary control), alone or in combination with pharmaceuticals, all seem to offer possibilities in attempting to obtain and maintain such a state. Control of the

temperature by influencing the heat regulating center would be more desirable than changing the reference level.

Oxygenization and Carbon Dioxide Removal. Breathing in space is a problem because the space environment will not provide the necessary oxygen, and respiration eliminates needed carbon dioxide and involves heat and water losses. An inverse fuel cell, capable of reducing CO_2 to its components with removal of the carbon and recirculation of the oxygen, would eliminate the necessity for lung breathing. Such a system, operating either on solar or nuclear energy, would replace the lung, making breathing, as we know it, unnecessary. Conventional breathing would still be possible, should the environment permit it, discontinuing the fuel-cell operation.

Fluid Intake and Output. Fluid balance in the astronaut could be largely maintained via a shunt from the ureters to the venous circulation after removal or conversion of noxious substances. Sterilization of the gastrointestinal tract, plus intravenous or direct intragastric feeding, could reduce fecal elimination to a minimum, and even this might be reutilized.

Enzyme Systems. Under conditions of lowered body temperature, certain enzyme systems would tend to remain more active than others. The extent to which pharmaceutical or chemical agents could influence this enzyme activity has not been systematically investigated, but beyond question they will play an important role. Since metabolism is subject to enzyme control, several intriguing possibilities exist. For example, it may be possible through in vitro radiation to convert certain organisms from aerobic to anaerobic states and, by studying changes in the enzyme systems, to adapt them for eventual human use. In the same manner, selected atmospheres of other types could be investigated.

Vestibular Function. Disorientation or discomfort resulting from disturbed vestibular function due to weightlessness might be handled through the use of drugs, by temporarily draining off the endolymphatic fluid or, alternately, filling the cavities completely, and other techniques involving chemical control. Hypnosis may also be useful for controlling vestibular function.

Cardiovascular Control. The application of control-system theory to biology has already yielded sufficiently fruitful results in studies of the multiple homeostatic functions of the cardiovascular system to indicate the possibility of altering the system by the Cyborg technique. Administration of presently available drugs, such as epinephrine, reserpine, digitalis, amphetamine, etc., by means of Rose injectors, offers one possibility of changing the cardiovascular functions so as to fit them for a particular environment. Alteration of the specific homeostatic references within or outside the brain, and electric stimulation, either as a means of regulating heart rate or affecting selected brain centers in order to control cardiovascular functioning, are other possibilities.

Muscular Maintenance. Prolonged sleep or limited activity has a deleterious effect on muscle tone. While reduction of body temperature and metabolism may reduce the magnitude of the problem, further investigation of the chemical reasons for atrophy appears necessary to develop adequate pharmaceutical protection to help maintain muscle tone on prolonged space voyages.

Perceptual Problems. Lack of atmosphere will create markedly different conditions of visual perception than those with which we are familiar. Attention should be given to providing a medium which would recreate some of the distortions to which we are accustomed, and to which the astronaut could become acclimated before takeoff. Part of the problem would come from searching for an adequate frame of reference, and in this regard the factors which influence autokinesis (and illusory movement) may have an influence on space perception problems. Investigation of whether pharmaceuticals would influence autokinesis is therefore desirable.

Pressure. Under pressure lower than 60-mm Hg, man's blood begins to boil at his normal body temperature. Therefore, if he is to venture out of his space vehicle without a pressure suit, some means must be found of reducing his normal operating temperature to a point where the vapor pressure of his fluids is no greater than the internal tissue pressures. This is another reason why lowering of body temperature is essential to avoid the use of constricting pressure suits.

Variations in External Temperature. While man will require the protection of a space ship or station at the real extremes of temperature, there are also likely to be intermediate conditions within or close to the limits of human tolerance. By controlling reflection and absorption by means of protective plastic sponge clothing plus chemicals already in existence which produce changes in pigmentation and provide effective protection against actinic rays, it should be possible to maintain desired body temperature. Needed is a light-sensitive, chemically regulated system which would adjust to its own reflectance so as to maintain the temperature desired.

Gravitation. A change in the ratio of gravity and inertia forces to molecular forces will alter mobility patterns, among other things. Body temperature control and other uses of pharmaceuticals could possibly improve functioning under conditions of greater or lesser gravitation than that on earth.

Magnetic Fields. Chemicals and temperature alteration might also act to retard or facilitate the specific effects of magnetic fields in space.

Sensory Invariance and Action Deprivation. Instead of sensory deprivation, it is sensory invariance, or *lack of change* in sensory stimuli, which may be the astronaut's bugaboo. In

End of the Line

Official AF photos show the 5000-mile Northrop SM-62 Snark missile release its nose, packing a dummy nuclear payload, in a practice run on a target. The nose will proceed at supersonic speed on a ballistic trajectory.

most of the sensory deprivation experiments to date, it has been sensory invariance which has produced discomfort and, in extreme circumstances, led to the occurrence of psychotic-like states. Of even greater significance may be action invariance, deprivation or limitation, since in many such experiments subjects have mentioned a "desire for action." The structuring of situations so that action has a meaningful sensory feedback should reduce these difficulties. Here again drugs could play a useful role in reducing resultant tensions. Action without demonstration that such behavior is purposeful or sensory stimuli without opportunity for appropriate response are both highly disturbing.

Psychoses. Despite all the care exercised, there remains a strong possibility that somewhere in the course of a long space voyage a psychotic episode might occur, and this is one condition for which no servomechanism can be completely designed at the present time. While an emergency osmotic pump containing one of the high-potency phenothiazines together with reserpine could be a part of the complete space man's kit, the frequent denial by an individual undergoing a psychotic episode that his thought processes, emotions, or behavior are abnormal, might keep him from voluntarily accepting medication. For this reason, if monitoring is adequate, provision should be made for triggering administration of the medication remotely from earth or by a companion if there is a crew on the vehicle.

Limbo. The contingency of possible extreme pain or suffering as a result of unforeseen accidents must also be considered. The astronaut should therefore be able to elect a state of unconsciousness if he feels it to be necessary. Prolonged sleep induced either pharmacologically or electronically seems the best solution.

Other Problems

There obviously exists an equally large number of medical problems amenable to pharmacological influence which have not been discussed here for lack of space. Among these are such conditions as nausea, vertigo, motion sickness, erotic requirements, vibration tolerance, etc.

However, those selected for discussion offer an indication as to what the Cyborg can mean in terms of space travel. Although some of the proposed solutions may appear fanciful, it should be noted that there are references in the Soviet technical literature to research in many of these same areas. Thus we find the Russians proposing prior oxygen saturation as a solution to the problem of respiration during the first few minutes after space vehicle launchings; reporting on alterations of the vestibular function both by drugs and surgery; studying perception and carrying out research on the laws of eye motion in vision; finding that lowering of temperature can aid in solving pressure problems; etc.

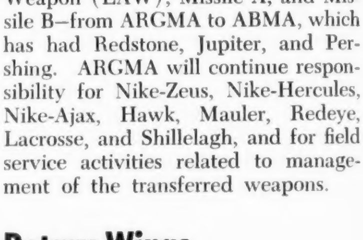
Solving the many technological problems involved in manned space flight by adapting man to his environment, rather than vice versa, will not only mark a significant step forward in man's scientific progress, but may well provide a new and larger dimension for man's spirit as well. ♦♦

A complete list of references for this paper may be obtained by writing to the Editor, Astronautics, 500 Fifth Ave., New York 36, N.Y.

Army Missile Transfer

August 1 the Army transferred seven surface-to-surface missile systems—Honest John, Little John, Corporal, Sergeant, Light Antitank Weapon (LAW), Missile A, and Missile B—from ARGMA to ABMA, which has had Redstone, Jupiter, and Pershing. ARGMA will continue responsibility for Nike-Zeus, Nike-Hercules, Nike-Ajax, Hawk, Mauler, Redeye, Lacrosse, and Shillelagh, and for field service activities related to management of the transferred weapons.

Rotary Wings For Re-entry



The AF's Wright Air Development Div. recently awarded Kaman Aircraft a contract for nearly a half-million dollars to develop and test a guided recovery device based on Kaman's Rotochute, shown above fixed to three payloads weighing from 100 to 200 lb and strung by a cable to the bottom one. The development will aim at a re-entry aid for manned space capsules, nose cones, and rocket boosters.

Lunar Guidance

(CONTINUED FROM PAGE 25)

a position accuracy of about 1000 ft, a vertical velocity accuracy of 20 fps, and horizontal velocity accuracy of 2 fps. Is this mission presently feasible as far as guidance is concerned, and if so, what guidance scheme is optimum with respect to the system's measure of effectiveness?

First, there are several problems related to this mission which are not completely solved. For example, if an optical system is used, what is the optimum wave length for the scanner? However, all of the problems can be solved simply by study; no breakthroughs are required. Even if the problems were not completely solved, the mission could still be a success but with nonoptimum vehicle performance. It can be shown that this mission is feasible under the constraints of the present state of the art. If the system measure of effectiveness is defined as maximum payload on the moon with minimum error for the particular mission under consideration, it is likely that the optimum guidance scheme would be as follows.

The lunar mission might be to soft-land an instrument package near the eastern edge of the moon at some latitude and longitude in the Ocean of Storms. For optimum performance a low-energy, $3^1/_4$-day trajectory would be chosen; optimum launch time and position would be chosen if feasible. (The illustration on page 24 presents a representative earth-lunar transit trajectory.) Employing an inertial-guidance system similar to those already in the ballistic missiles, such as Atlas or Minuteman, a cutoff accuracy could easily be attained which would effect lunar impact without trajectory modification. Then, for a midcourse guidance system, an inertially stabilized platform and highly accurate telescope would be used. Attitude control would be maintained very precisely by monitoring the gyros and correcting them with information from the telescope. (Two telescopes might be better, with one continually monitoring the gyros.) By tracking the earth, moon, and a star, the telescope would gain sufficient information to eliminate gyro drift as a problem. Since midcourse and terminal rockets would be fired for trajectory modification, very accurate attitude control would be a necessity. The telescope could track the center of the earth and the center of the moon, measuring the angles between the lines to their centers and three coordinate axes of the reference platform, so that deviations from a reference trajectory could be determined.

Two midcourse corrections, one at about 90,000 miles and the other one at about 20,000 miles from the moon would be sufficient for delivering the vehicle to the neighborhood of the moon with high enough accuracy in velocity and position for a terminal-guidance system to assume command. The more midcourse corrections that are made, the easier the problem becomes in the terminal stage, and the greater is the accuracy attainable there. However, for a 1000-ft CEP at lunar impact and vertical approach, two midcourse corrections seem to be an optimum. This technique for midcourse guidance can give an accuracy on the order of 5 to 15 miles without terminal correction. That is, if guidance error alone is considered, it can be shown that a 20 sec error in the angular measurement will cause no more than about 5 miles of error at impact under the conditions stated here for midcourse corrections. For the initial lunar missions, a 20 sec error will not be attainable because of the severe weight limitation on the guidance system. An accuracy of 1-min angular error will be more likely, with a resulting terminal error of about 15 miles without terminal correction. This does not account for error in the constants of the system and uncertainty of thrust cutoff. However, when these are considered the error added is only about 10 or 15 miles. Without terminal correction, the correction points might be moved closer to the moon; and although more propellant would be required, slightly greater accuracy could be attained.

In order to determine the terminal-guidance requirements, it is sufficient to consider the initial conditions in the terminal phase; or, equivalently, the terminal conditions in the midcourse phase, and the required terminal position and terminal velocity accuracy. The initial conditions are specified by the magnitude of the velocity and position error at the end of midcourse. For the mission we are considering, 1000-ft CEP is the required terminal position accuracy, 20 fps is the allowable vertical velocity error, and 2 fps is the allowable horizontal velocity error. Thus, the problem is to determine the deviation from the trajectory and to modify the trajectory as was done in the midcourse phase. Also there is the problem of nulling out the relative moon-vehicle velocity to effect the soft landing.

Part of the midcourse guidance equipment can be used in the terminal phase, permitting a reduction in weight of the complete guidance system over nonintegrated systems and thus allowing more instrumentation in the payload for data gathering. Assuming the same telescope as was used for the midcourse guidance, in conjunction with detailed maps of the moon, a map-matching technique for the terminal phase can be devised. The number of maps and detail of the maps will depend on the expected landing point, for at some places on the moon the terrain is very variable and at other places it is fairly constant. The large maria are generally fairly level, so that less detail and fewer maps would be required for them than for other areas. For soft landing in the Ocean of Storms, one map would suffice as long as the landing was well away from its craters.

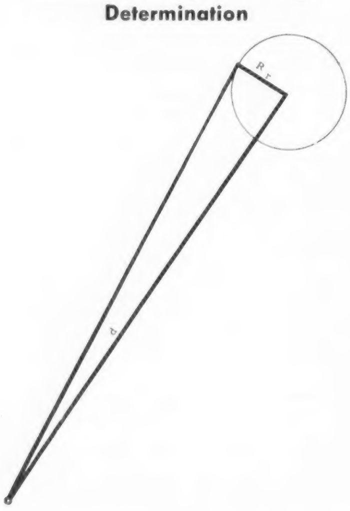
Present maps of the moon are rather inaccurate for use in a precise navigation scheme. However, a topographical map of the moon is presently being prepared by the U.S. Army Map Service and the U.S. Geological Survey, and should be completed by October 1960. Considering the fact that already over 3000 points on the moon are known with a probable position error of 1000 ft and that altitudes can be determined fairly accurately through shadow methods, it seems reasonable to consider map comparison as a possible technique for terminal

navigation. The final accuracy, however, will depend partially on the map that is presently being prepared. The 1000-ft CEP prescribed earlier for the soft lunar landing mission does not take into account the errors in the maps.

The first soft lunar landings will probably employ a vertical approach to the moon's surface rather than tangential or something between. This is the approach which seems simplest and which has been studied most. In this case the optimum scheme would be to use two retro-impulses to slow the vehicle from 9000–10,000 to 0 fps and to correct the error inherited from midcourse conditions. The first retro-impulse could be made 200 or 300 miles from the lunar surface, and the second one during the last few thousand feet, so that both velocity components reduce to zero in the altitude interval of 0 to 75 ft above the lunar surface. Further, since the last correction is made at low altitude, the retrorocket will have to be the high-thrust type. It seems wise, both in terms of fuel economy and accuracy, to make the terminal corrections at near minimum altitudes and to use high-thrust retrorockets close rather than low-thrust rockets at higher altitudes. This is not altogether true, but rather depends on the lunar approach.

As the vehicle nears the moon, it may become impossible to determine the vertical optically with the necessary accuracy. Both the midcourse and terminal guidance systems will use vertical information. Thus it seems reasonable to determine at what range the optical vertical accuracy starts to decay and then use some gyro arrangement to hold the vertical (as determined, say, at 5 lunar radii) until vehicle touchdown. Since both horizontal and vertical velocity modifications would usually be made in the last two corrections, there would occur changes in lunar latitude and longitude. In order to sense this change, it would be necessary to be able to determine the local vertical.

Geometry for Optical Range Determination



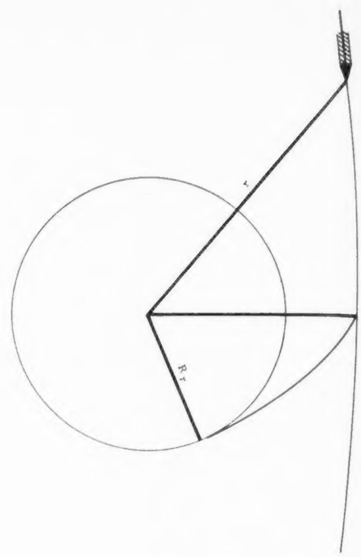
Semihard Landing

The first lunar mission which this country will undertake will probably be a hard landing. This is a natural starting point, since it is the simplest mission which will still yield significant scientific information. As mentioned, the present ICBM guidance system has sufficient capability for this mission if impact at any point on the lunar surface is satisfactory. The missions next to be considered will be impacting in a given region, semihard landing, and orbiting the moon. These missions will require more than initial guidance. One possibility where high accuracy is not desired is to make only one midcourse or terminal correction for all but the semihard landing. For this mission a terminal slowdown is required.

Using a telescope to track the moon, the range from the vehicle to the moon can be determined as indicated by the diagram shown below. The telescope determines the angle, α, subtended by the moon's radius at the vehicle, and a digital computer determines the range, r, from the appropriate formula. Having the range continually provided, the digital computer can determine the radial velocity continuously. A stable platform can be used to determine the horizontal velocity component. Having this information, it is simple enough to compute the two-body hyperbolic orbit of the vehicle with respect to the moon, as indicated by the diagram top right. Knowing this trajectory, it is then possible to compute in advance the required velocity increment to modify the trajectory for purposes of orbiting the moon, impacting in a given area, or semihard impacting. The trajectory modification requires firing a rocket. Very good attitude control is therefore required, as is some technique for getting the correct velocity increment.

With good attitude control, an accelerometer may be used to monitor the rocket thrust so that the thrust may be terminated or the rocket released at the correct time. The gyroscopically stabilized platform and telescope furnish sufficient information for attitude control. Thus, the major components of the guidance system would be a tracking telescope, a stabilized platform, a digital computer, an accelerometer, a guidance rocket, and a clock.

Orbital-Transfer Geometry



If, for example, it is desired to transfer from the hyperbolic-approach orbit to an elliptical orbit with given eccentricity, the velocity change required at a point in advance of the vehicle may be determined. The digital computer can monitor the trajectory to determine when to fire the rocket. When the vehicle reaches this point the rocket is fired and when the required velocity increment is reached, as determined by the accelerometer, the rocket is released from the vehicle.

For the NASA semihard landing Ranger project this approach is too sophisticated. Since the total payload will be about 300 lb and the rocket itself will weigh about 200 lb, very little is left for a guidance system if much scientific data are to be gathered. Futhermore, since a rocket will be fired, good attitude control is required. It would appear that no on-board terminal system will be feasible with Ranger, other than perhaps a clock which automatically fires the rocket after an assigned passage of time. For larger payloads, however, the use of a tracking telescope, stabilized platform, etc., as discussed above, certainly should be considered. Having a sophisticated terminal-guidance system would permit not only closer tolerances on the terminal velocity but would furnish information for trajectory modification, so that the landing could be made more precisely with respect to position.

More specifically, consider the mission of orbit transfer in the vicinity of the moon using a rather simple optical-inertial terminal-guidance system. Assuming an opportune time and place for the launch, a cutoff velocity of

Guidance for Lunar Missions

Lunar Mission	Minimal Guidance	Goal	Vehicle	Optical-Inertial Guidance
Hard impact	Initial	1961	Atlas-Agena	No
Semihard impact (terminal slowdown to about 500 fps)	Initial with some technique for determining when to fire the retrorocket	1962	Atlas-Centaur	Not for initial missions since payload is very small. Yes, when payload increases.
Lunar orbit (terminal slowdown to elliptical or circular velocity)	Initial and midcourse or initial and terminal	1962	Atlas-Centaur	Yes
Lunar soft landing (terminal slowdown to less than 50 fps)	Initial, midcourse, and terminal	1965	Centaur and Saturn	Yes
Manned lunar landing (terminal slowdown to less than 10 fps)	Initial, midcourse, and terminal	1970	Nova	Yes

35,000 fps at 350-statute-miles altitude will bring the vehicle into the vicinity of the moon in a little over two days with a terminal error volume considerably smaller than the moon. The moon would be missed on purpose, but the hyperbolic trajectory would pass within 1000 miles or so of its surface as a result of the initial guidance. Smaller velocity values than 35,000 fps can be chosen, but the flight time and probably the terminal error will be larger. The approach trajectory will be hyperbolic at a velocity of about 10,000 fps.

Now consider the problem of transferring from the approach orbit at perigee to a circular orbit about the moon. (Perigee as used here means the minimum distance between the center of the moon and the trajectory.) The problem is that of reducing the hyperbolic velocity, V_H, to a circular velocity, V_C. The following two relationships can be written: $V_C^2 = K/r$ and $V_H^2 > 2K/r$ where $K = 1.7270 \times 10^{14}$ ft^3/sec^2. The constant K is called the gravitational parameter. To transfer from the hyperbolic orbit at perigee to a circular orbit, it is necessary to reduce the velocity from something greater than $2K/r$ to K/r. Therefore it will be necessary to compute the hyperbolic velocity and the circular velocity. This can be done in the following way.

Using a disk-scanning telescope, the value of r can be determined. Then, through the use of a stable platform, the hyperbolic trajectory can be computed so that the value of r at perigee can be predicted. Finally, by solving the equations of motion, the following formula for the perigee distance can be derived

$$r_p = \frac{-R_m^2 g_m + (R_m^2 g_m + c_2 c_1^2)^{1/2}}{c_2}$$

where r_p is the perigee distance; R_m is the radius of the moon; g_m is the acceleration of gravity at the lunar surface; and c_1 and c_2 are integration constants which can be computed from the telescope and stable-platform outputs.

This equation and the first one cited give the velocity required at perigee to transfer to a circular orbit. The determination of the actual velocity, $r_p\dot{\theta}_p$, can also be predicted ahead of time. So the actual velocity change required for orbit transfer at perigee is given by

$$\Delta V_p = \frac{K}{r_p} - r_p\dot{\theta}_p$$

This is determined in advance of perigee, so that there is plenty of time for smoothing the data. At some point on the trajectory, the telescope and stable platform begin to monitor the trajectory for perigee. When perigee is reached, $\dot{r} = 0$, $\dot{\theta}$ attains a maximum, the rocket is fired to modify the velocity, and the vehicle goes into a circular orbit.

In conclusion, we observe that the two principal lunar guidance systems being considered presently are radio and optical-inertial. Each of these has advantages, but the application of optical-inertial to interplanetary systems gives it an advantage in systems where growth possibilities are important. The table shown above summarizes missions for optical-inertial systems.

Suggested Additional Reading

"Principles of Guided Missile Design, Space Flight" by Kraft Ehricke, D. Van Nostrand Co., Inc., Princeton, N.J., Edited by Grayson Merrill, Captain U.S.N. (Ret.), 1959.

"Space Handbook: Astronautics and Its Applications," Staff Report of the Select Committee on Astronautics and Space Exploration, U.S. Government Printing Office, Washington, 1959.

"Space Technology," Edited by Howard Seifert, Based on a Univ. of California Engineering Extension Course, John Wiley and Sons, Inc., New York, 1959.

"Motion of a Small Body in Earth-Moon Space," by R. W. Buchheim, The Rand Corp., Research Memorandum RM-1726, June 4, 1956.

"An Introduction to Celestial Mechanics" by F. R. Moulton, Macmillan, New York, 1914.

"Astrodynamics" by S. Herrick, Princeton, N.J., D. Van Nostrand, 1959. ♦♦

Missile market

By Jerome M. Pustilnik, *Financial Editor*

"AN OPEN door leading investors onto the ground floor of many of the most promising, explosively growing appliéd science companies." This metaphor describes a new—and most remarkable—investment concept, the publicly owned Small Business Investment Company (SBIC), particularly those that specialize in technologically oriented companies.

What is an SBIC? By law, a company organized under the Small Business Investment Act of 1958. This Act permits the SBIC to invest in businesses with assets of less than $5 million, and whose annual average earnings for the preceding three years have not exceeded $150,000, after taxes. Investments are made in the form of convertible debentures of the client company, which, at the option of the SBIC, can be converted into common stock. The SBIC accumulates substantial capital for these investments through public sale of its own shares. Also, by availing itself of the provision in the law which permits the SBIC to borrow from the government a sum equal to half of its paid-in capital and surplus, the SBIC can further augment its funds while gaining leverage for its shareholders.

But this legalistic language nearly smothers the excitement of the SBIC idea—finding and investing in small firms of dramatic growth potential *before they become publicly owned*. Each of these aspects of an SBIC's operations merits discussion.

Finding the best firms in which to invest requires scientific training, engineering knowhow, and an investment banker's underwriting experience. For these reasons, the board of directors and top executives of those SBIC's specializing in applied science companies are composed of men prominent in just these areas. Scientists, outstanding in a specific discipline, are also consulted.

But finding a company of great growth potential is meaningless, unless a sufficient investment can be made in it, thereby obtaining significant exposure to this growth, if it occurs. With its large fund of capital, an SBIC can do just that.

To illustrate the importance of this point, consider the example of Transitron Electronics Corp. Very few readers of *Astronautics* were unaware of this semiconductor manufacturer even while it was privately owned. Yet very few probably were able to obtain any stock at the initial offering price when the company first became publicly owned; and probably fewer still could wangle more than a token number of shares from investment dealers. But, of those that did, imagine the immeasurably greater appreciation their investment could have enjoyed had it been made earlier, while Transitron was still a privately held company, growing explosively.

	August 1960	July 1960	% Change	August 1959	% Change
Dow-Jones Industrials	617	655	−5.8	675	−8.6
Missile Index	978	1035	−5.5	1059	−7.7

Thus the SBIC's unique ability—*finding and investing* in small privately owned firms of great growth potential—enables the investor to "get in on the ground floor." This can be immensely profitable over the years if these client companies fulfill their potentials. For this reason the remarkable advantages of investing in an SBIC will only inure to the long-term holders. Whenever an investor is fortunate in finding genuinely dynamic growth, he should play the role of the holder rather than the trader.

Stockholders in an SBIC also enjoy unusual tax advantages. Any losses they may sustain on the sale of an SBIC's stock are a complete deduction against ordinary personal income, absolutely without limit. This applies not only to initial investors, but to all subsequent investors as well.

Many SBIC's have been organized during the past two years; and several plan to invest only in technologically oriented companies. Here are thumbnail sketches of some of the larger and better known SBIC's.

Electronics Capital Corp. is not only the granddaddy but the largest SBIC. Its total lending capacity can be in the neighborhood of $80,000,000, of which almost $17,000,000 is paid-in capital.

ECC has invested only about one third of its capital thus far; but the company recently reported that they are engaged in serious negotiations with more than a score of promising companies. Investments have been made in the following companies: Ultronix (R & D on electronic components and subassemblies for missiles and space vehicles); Electronic Energy

Conversion Corp. (leader in the field of electronic energy conversion); Vega Electronics Corp. (analog data storage devices, widely used in telemetry and automation projects); General Electrodynamics Corp. (manufacturer of a wide variety of electronic products from TV camera tubes to airway traffic control components); Potter Instrument Co. (producer of magnetic tape for digital computers and related electronic data processing systems); Duncan Electronics (specialist in multiturn precision potentiometers and electronic component subsystems); Cain & Co. (a nationwide sales representative marketing electronics equipment).

Electronics Capital Corp. is directed by Charles E. Salik, president; Richard T. Silberman (formerly a vice president and director of Cohu Electronics); Neil H. Jacoby (director and dean of the UCLA Graduate School of Business Administration and former member of President Eisenhower's Council of Economic Advisors); Joseph M. Pettit (director and dean of Stanford Univ.'s. School of Engineering); Clarence A. Wetherill, senior technical officer of ECC (formerly assistant chief electrical engineer of Convair and chief engineer of Stromberg-Carlson).

Midwest Technical Development Corp. has, as a result of a recent underwriting, paid-in capital of about $5,000,000. Organized in October 1958, Midwest has investments in the following companies: Avien (development and manufacture of precision electric fuel measuring systems for aircraft); Electro-Logic Corp. (plans to introduce a low-cost digital-indicating voltmeter and components in low-cost data conversions systems); Kauke and Co. (produces proprietary products and special equipment and systems for telemetering applications); Lumen (high precision magnetic amplifiers for control systems and instrumentation applications); Minco Products (temperature sensing and control instruments for industrial and military applications); Narda Ultrasonics Corp. (manufacturer of ultrasonic equipment); National Semiconductor Corp. (semiconductor devices); Soroban Engineering (specialized input and output equipment for data processing systems); Telemeter Magnetics (memory components and systems for application in electronic computers, and in data control systems and automation systems); Telex (broad line of communications accessory products); Washington Machine & Tool Works (a manufacturer of high precision gear trains and electromechanical instrument assemblies).

Among Midwest's management group are Neal R. Amundson, director (professor and head of Dept. of Chemical Engineering, Univ. of Minnesota); Willis K. Drake, vice-president and director (formerly director of marketing of Control Data Corp.); Byron D. Smith, vice-president and director (formerly chief engineer—Product Planning of the Remington Rand Univac Div.); Erwin Tomash, director (president of Telemeter Magnetics).

Greater Washington Industrial Investments is among the newer companies. After having been organized late in 1959 it raised $4,500,000 through a public stock issue just three months ago. Although Greater Washington has yet to make any investments the high caliber of its management and directorate indicate a favorable future. Its board of directors include Eugene M. Zuckert (board chairman, Nucleau Science and Engineering Corp. and director of AMF Atomics); Daniel W. Bell (board chairman, American Security and Trust Co.); Everett J. Boothby (board chairman, Washington Gas Light Co.); James M. Johnston (senior partner of the investment bankers Johnston, Lemon & Co., director of Southern Oxygen Co. and director of Atlantic Research Corp.); Richard A. Norris (president of The Riggs National Bank of Washington, D.C.). ♦♦

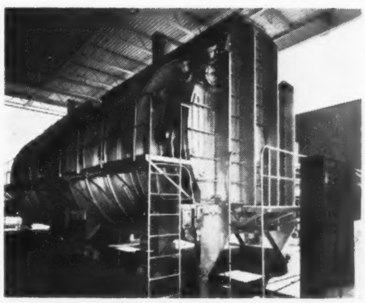
Powerful Magnet for MIT

A new research laboratory with generators for producing a continuous magnetic field as strong as 250,000 gauss—perhaps the most powerful in the world—will be built at the Massachusetts Institute of Technology under a $9.5 million contract between MIT and ARDC. Director of the new lab, scheduled to be in full operation by 1964, will be Benjamin Lax of MIT's Lincoln Laboratory. Francis Bitter, an associate dean of science at MIT, noted for his development of magnets, will direct its design and construction.

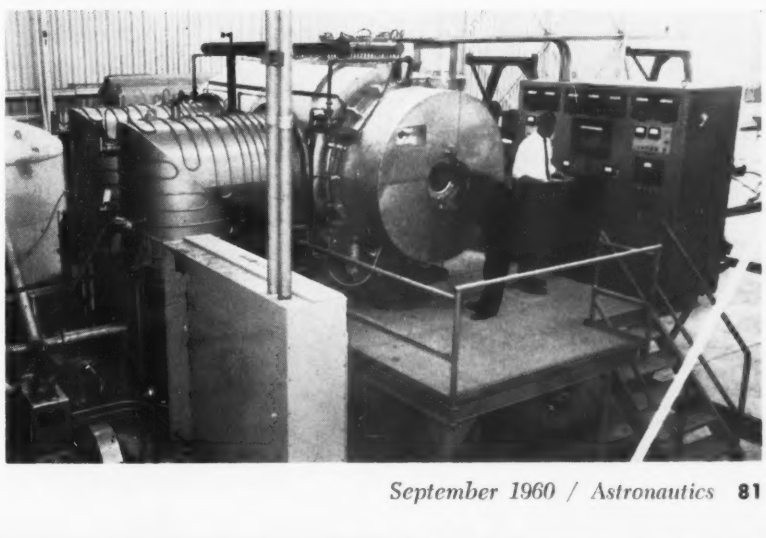
Eniwetok Part of PMR

Eniwetok Proving Ground, with its various tracking facilities, has been made available as part of the terminal facilities of the Pacific Missile Range.

New High-Vacuum Convair Facilities



Left, interconnected 35-ton high-vacuum tanks, each 20 x 12 ft, recently installed by the AF at Convair (Astronautics') new space research laboratory, will test small experimental rockets and satellite instrument packages at simulated altitudes up to 100 miles under extreme conditions of heat and cold. Below, Convair's ultrahigh-vacuum test chamber, now in operation after several months of calibration, produces near-perfect measurements at 10^{-8} mm Hg—the equivalent of 250-mile altitude—and temperatures between −300 and 700 F. This chamber will test electronic components and pressure units for space vehicles and satellites.



NEW PRODUCTS CATALOGUE

EQUIPMENT . . . PROCESSES . . . MATERIALS . . . LITERATURE

Amplifiers

Broadband Microwave. Frequency range 4 to 8 kmc/s; saturated power output-1 w min, 25 db min; external amplitude modulation; wt, 55 lb. **Alfred Electronics,** Palo Alto, Calif.

VHF. Provides better than 3-octave coverage; 20-db gain and low noise figure; using 5 tubes, power requirements are 22.5 anode power, 9.5-tube heater power; wt, 7.25 lb. **Applied Research, Inc.,** Port Washington, N.Y.

Solid-State Traveling-Wave. Used to increase strength of radio signals over a broad range of frequencies in the microwave range above 1000 meg; uses tunnel diodes. (Illustrated.) **Bell Telephone Laboratories,** New York, N.Y.

Transistorized DC. Average temperature coefficient of voltage offset less than 5 microvolts/C over −65 to 85 C; silicon junction diode. **Bendix Corp.,** Research Laboratories, Southfield, Mich.

Combination. Servo amplifier-power supply for industrial automation; transistorized; receives signals from synchro control transformer; operates 8-w or smaller servo. **M. Ten Bosch, Inc.,** Pleasantville, N.Y.

Buffer Preamplifier. Input impedance, 5 meg constant resistive at a gain of 1 at signal-in connection; output impedance 1000 ohms max; max output, 1 v rms; wt, 1 oz. **Bulova Watch Co., Inc.,** Woodside, N.Y.

Low-Noise Preamplifier. Self-contained battery power supply; high gain of 10,000 and bandwidth of 10 cps to 20 kc; output impedance, 600 ohms; wt, 1 lb. **Comptometer Corp., Radiation Electronics Co. Div.,** Chicago, Ill.

Servo-Tuned. Amplifier and power supply for use with power transmitters operating in the 225–400 mc band; amplifier, 38 lb; power supply, 32 lb. **Electronic Communications, Inc.,** St. Petersburg, Fla.

Laboratory System. Monitors and amplifies vibration, shock, pressure, and force signals; each amplifier section contains voltage amplifier, power amplifier, and meter. **Endevco Corp.,** Pasadena, Calif.

Magnetic Modulator. Input 115 v at 400 cycles; output 0–3 v and 0–2.5 v with reversible phase; DC signal input 0–±100 microamps; load 12,000 ohms. **Freed Transformer Co., Inc.,** Brooklyn, N.Y.

Dual-Channel Buffer. Drives any resolver with a tuned primary impedance of 2000 ohms and primary resistance of −1000 ohms; max signal output 26 v. **General Precision, Kearfott Div.,** Little Falls, N.J.

Additional information about any of the products, equipment, processes, materials and literature listed on these pages may be obtained by writing to the New Products Department, ASTRONAUTICS, 500 Fifth Avenue, New York 36, N. Y.

DC-to-DC. Input mechanical modulator, high-gain AC amplifier, and electrical demodulator output; input impedance 100,000 ohms; DC-to-DC gain, 25,000. **General Precision, Inc., Kearfott Div.,** Little Falls, N.J.

Micro-miniature. Integrated circuits consist of vacuum-depositing simultaneously all interconnectors, resistors, and capacitors and inserting diodes and transistors to form monolithic structure 3/8 in. sq by 1/8 in. **Halex, Inc.,** El Segundo, Calif.

Ruby-Maser. Detects signals from space vehicles; range of millions of miles; uses 1/2-in.-sq synthetic ruby maser cooled to −450 F by liquid helium. **Hughes Aircraft Co.,** Culver City, Calif.

Video. Transistors and subminiature tubes; captures faint picture signals; covers broad band from 100 kc to 200 mc. **Instruments for Industry,** Hicksville, N.Y.

Miniature Servo. Developed to drive flight attitude indicators, positioning gimbals, gyros, platforms, and compass systems; also used in computing instruments; volume, 0.9 cu in. **Lear, Inc.,** Santa Monica, Calif.

Low-Level DC. Chopper-stabilized; accepts signals from 5 uv to 1 v; capable of indicating on its own panel meter or recording on a meter tape recorder; wt with cabinet, 10 lb. **Magnetic Instruments Co.,** Thornwood, N.Y.

DC Signal. Model 10-108-2 operates from 115 v–400 cycle power; Model 12-105-0 for 28 v DC; used for temperature and strain measurements; produces output signal from 0–5 v. **Magnetic Research Corp.,** Hawthorne, Calif.

Mesa. For high-frequency applications, including video; cutoff current of 0.2 ma make it useful for critical DC direct-coupled service. **Motorola, Inc., Semiconductor Products Div.,** Phoenix, Ariz.

Data. Each channel of amplification requires 15-v DC at 150 ma, −15-v DC at 75 ma, and 6-v 400 cps at 30 ma; 8 channels in 8.75 in. of rack space. **Offner Electronics, Inc.,** Schiller Park, Ill.

Differential-Input. Gains of 100, 250, 500, and 1000 are selectable by panel switch; 2 amplifiers in each module; 16 channels in 8.75 in. of rack space. **Offner Electronics, Inc.,** Schiller Park, Ill.

Solid-State DC. Frequency response exceeding −3 db at 200 kc; gain accuracy ±0.03%; linearity and stability ±0.02%; drift 500 uv referred to input. **Packard Bell Electronic Corp.,** Los Angeles, Calif.

Signal. Incorporates integral regulated power supplies; negative feedback stabilizes frequency response balanced for both AC and DC; voltage gain from 200 to 2000. **Regulators, Inc.,** Wyckoff, N.J.

Intermediate-Frequency. Uses silicon transistors; operates with center frequency of 30 mc and bandwidth of 3 mc; gain of 60 db; gain control. **R. S. Electronics Corp.,** Palo Alto, Calif.

Klystron. Four klystron tubes give range of 7.125 to 8.5 kmc; gain in excess of 40 db when operated as broadband amplifier. **Sierra Electronic Corp.,** Menlo Park, Calif.

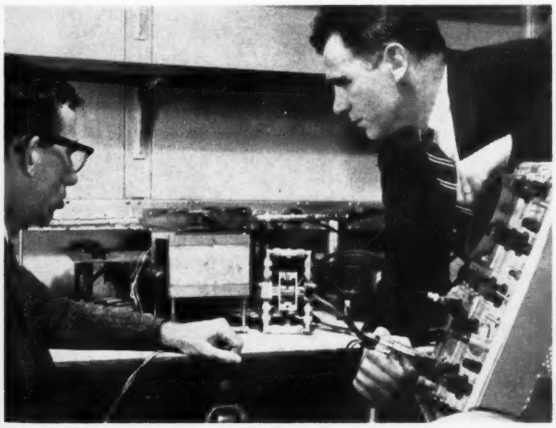
DC. Converts low-level DC input to ±2.5 DC output; 0.5% best straight line linearity; gain stability, 0.5% full scale of 25 C value; less than 5 k output impedance; 20 mv peak-to-peak ripple. **Temco Aircraft Corp.,** Dallas, Tex.

Antenna Amplifier/Coupler. Mounted at antenna terminals; provides 10 db of gain from 2 to 40 mc with noise figure less than 6.5 db and low distortion. **Trak Electronics Co.,** Wilton, Conn.

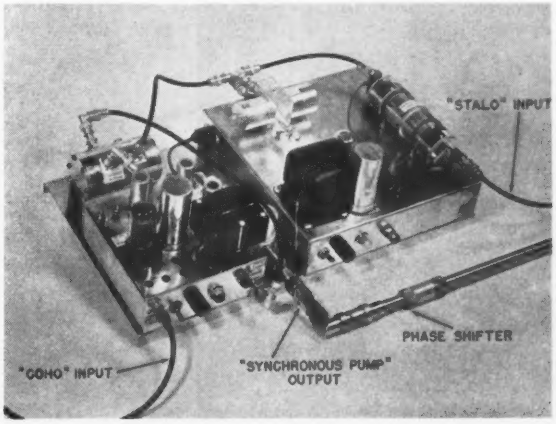
RF-Power. For use with any 1 to 5 w RF transmitter in 215–260 mc telemetering bands; power input, 1.8 w nominal; output 10 w min. **United ElectroDynamics, Inc.** Pasadena, Calif.

Pentode-Tube. Voltage regulators and amplifiers useful in critical TB, oscilloscope and regulator circuits; three types capable of handling 1000, 4000, and 10,000 v respectively. **Victoreen Instrument Co.,** Cleveland, Ohio.

Peak-Following. Used to amplify signals from crystal-type accelerometers; up to 100-ma output; input impedance in excess of 1000 megohms; bandwidth from 5 cps to 5 kc. **Video Instruments Co.,** Santa Monica Calif.



Bell Labs Experimental Solid-State Traveling-Wave Amplifier



Zenith Synchronous-Pumping High-Frequency Amplifier

Servo. Model A419, normally used with a direct-coupled center-tapped servometer; input impedance, 10,000 ohms; input signal, 25 v max allowable. **Westamp Inc.,** Los Angeles, Calif.

High-Frequency Synchronous. Synchronous pumping technique for radar; frequency response flat over band of about 80 mc centered at 1300 mc; gain adjustable from −1 to 30 db by varying pump power. (Illustrated.) **Zenith Radio Corp.,** Chicago, Ill.

Data Processing

Digital Data Recorder. Up to 8 channels and any digital coding accommodated on narrow papertape perforated electronically with patterns of small holes. **Advinco,** Richmond, Calif.

Graphic Pulse Recorder. Uses high-fidelity electrosensitive recording paper and high-speed techniques; records impulses from radar or sonar echoes and other outputs and signals. **Alden Electronic & Impulse Recording Equipment Co., Inc.,** Westboro, Mass.

Wideband Airborne System. Airborne and ground units that record two channels of wideband information over 10 cycles to 4 mc. **Ampex Corp.,** Redwood City, Calif.

Time-Speed. Monitoring automated operations, provides split-second timing and "time-of-day" information; chart speeds of 3/4, 1 1/2, 3, 6, and 12 in/hr and in/min; 115 v 60 cycles. **R. B. Annis Co.,** Indianapolis, Ind.

Time-Temperature. Continuously displays jet exhaust gas temperature and records duration of overtemperatures; wt, 5.5 lb. **Avien, Inc.,** Woodside, N.Y.

Central Processor. Built of solid-state components (5000 transistors and 30,000 diodes); has an expandable random-access magnetic-core memory consisting of 1 to 8 modules of 4096 words each. **Bendix Computer Div.,** Los Angeles, Calif.

Magnetic Heads. Series 2000, available in six tape formats; 2.38-in.-long double head assembly for integral interlace or redundant analog recording. **Clevite Corp., Electronics Components Div.,** Cleveland, Ohio.

Portable Processor. Model BSA-250, 40-mm amplitude two-channel rectilinear recorder; consists of a basic system assembly and any two Massa interchangeable plug-in preamplifiers—low, medium, and high gain DC. **Cohu Electronics, Inc.,** Massa Div., Higham, Mass.

Logger. System samples 210 channels of analog data per minute sequentially, commutates and converts them, and punches data in paper **Consolidated Electrodynamics Corp.,** Pasadena, Calif.

Automatic Degausser. Used with tapes from 1/4 to 2 in. wide, reels from 7 to 14 in. in diam, and reel hubs of all dimensions; wt, 80 lb. **Consolidated Electrodynamics Corp.,** Pasadena, Calif.

Recorder/Reproducer. All-solid-state type PR-2300; records up to 14 channels of direct-record or wide-band FM analog data and plays back bidirectionally; wt, less than 150 lb. (Illustrated.) **Consolidated Electrodynamics Corp.,** Pasadena, Calif.

Re-entry Recorder. For recording data during re-entry in an ICBM nose cone; in container, 5.34 in. in diam by 7 in. long; withstands impacts up to 400 g. (Illustrated.) **Cook Electric Co., Data Stor Div.,** Skokie, Ill.

Printing Bulb. Developed for high-speed electronic printing; has 35,000 separate wire conductors imbedded in faceplate 3 x 1/4 in. (Illustrated.) **Corning Glass Works,** Corning, N.Y.

Recorders. Equipped with either 1 to 2 set points for maximum-minimum control; maximum set-point range, 30 to 100% full-scale; minimum set point, 0 to 70 per cent full-scale. **Curtiss-Wright Corp.,** Electronic Instrument Dept., Princeton, N.J.

Temperature. Measures and records up to 75 iron constantan thermocouple inputs; three temperature ranges: −30 to 120 F, 250 to 600 F, and 0 to 1200 F. **Datex Corp.,** Monrovia, Calif.

Digital. Model 960 transfers digital information to permanent record at rates up to 150 lines or words of 32 bits each per sec; compatible with digital data sources. **Electronic Computers, Inc.,** Syosset, N.Y.

Digital Printer. Solid-state automatic printer, complies with MIL-E-4158B; capacity, 11 col.; prints 5 lines per sec. **Epsco, Inc., Equipment Div.,** Cambridge, Mass.

Voltage-Variation Detector. Records voltage values in ink on graph paper; picks up variations or transients as small as 2 v with duration of less than 32 millisec. **Esterline-Angus Co.,** Indianapolis, Ind.

Multiplexing Data. Transmitter and receiver handle up to 7 channels of 3-wire synchro data for FM transmission over long distances. **Feedback Controls, Inc.,** Natick, Mass.

Data Logger. Model 179 for strain-gauge, thermocouple, and millivolt outputs; prints out decimally 100 channels of data in 20 sec. **Gilmore Industries,** Cleveland, Ohio.

Strain-Gauge Plotter. For on-the-spot plotting of structural stresses in rocket-engine casings and pressure vessels; scans 20 channels per sec of strain vs. per cent load, or strain vs. pressure. **Gilmore Industries,** Cleveland, Ohio.

Readout Device. Randid (rapid alpha numeric digital indicating device) photographically reproduces characters or symbols on a belt, appearing transparent on an opaque background. **Hazeltine Corp.,** Little Neck, N.Y.

Instrumentation Unit. Plug-in device requires no additional aircraft wiring for signals or power when installed; uses 12-channel oscillograph recorder; provides for 16 commutated signals, 8 commutated channels, and 7 channels of electronics. **Hughes Aircraft Co.,** Culver City, Calif.

Magnetic-Tape Transmitter. Model 7701 transmits or receives magnetic-tape data over telegraph or telephone lines at a speed of 150 characters per sec; fully transistorized. **IBM Data Processing Div.,** White Plains, N.Y.

Digital Subset. Feature adapts IBM data transceiver for operation over conventional dial telephone lines at regular message rates. **IBM Data Processing Div.,** White Plains, N.Y.

Transmissibility Recorder. Permits continuous direct recording of vibration transmissibility and a function of frequency, giving a ready-to-use curve. **Lord Mfg. Co.,** Erie, Pa.

Spectral Recording Instrument. Suitable for such field use as the observation of atomic flashes; large aperture; portable. **Melpar Inc.,** Falls Church, Va.

High-Gravity Oscillograph. Model 560A records 14 different data traces on a 3 5/8-in.-wide paper or film; can be installed in missiles, rockets, or other units; wt, 10 lb. **Midwestern Instruments,** Tulsa, Okla.

Digital Tape System. Model M3000 has tape speeds of 112.5 120, and 150 ips; tape width, 1/2 or 1 in.; wt, 600 lb. **Midwestern Instruments,** Tulsa, Okla.

Flight Recorder. Monitors up to 65 variables; playback accomplished through use of aircraft instrument display, a Visicorder, digital counter and printer, or large-scale digital computer; developed for FAA. (Illustrated.) **Minneapolis-Honeywell Regulator Co.,** Minneapolis, Minn.

Multipoint Recorder. Strip chart convertible to change the number of points being measured, the actuation, or the range; for application in processes requiring frequent record changing. **Minneapolis-Honeywell Regulator Co.,** Minneapolis, Minn.

Magnetic Tape System. Model CM-100 videoband recorder/reproducer packs in a single standard-size rack; each of seven tracks covers an over-all bandwidth of 400 cy to 1.0 mc; single 1/2-in. tape travels at from 7.5 to 120 ips. (Illustrated.) **Minnesota Mining and Mfg. Co., Mincom Div.,** Los Angeles, Calif.

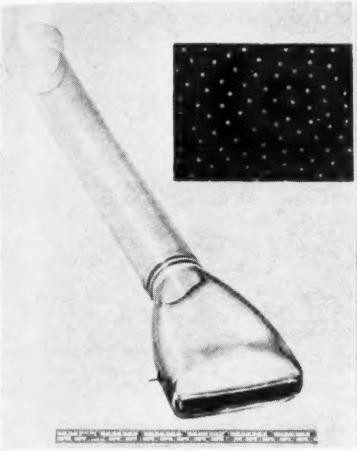
Digiprinter. Operates on 115 v AC, 60 cycles power; provides visual digital readout of weight, pressure, position, voltage, current, temperature, and resistance measurements. **Moran Instrument Corp.,** Pasadena, Calif.

Tape Translator. Model 44 accepts data prepared on IBM units operating in the low-density mode; produces graphic display of data recorded on magnetic tape; plotting speed, 100 ppm at 1/2-in. spacing. **F. L. Moseley Co.,** Pasadena, Calif.

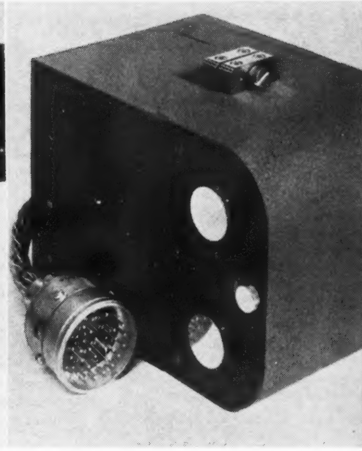
Wideband Airborne System

Recorder/Reproducer

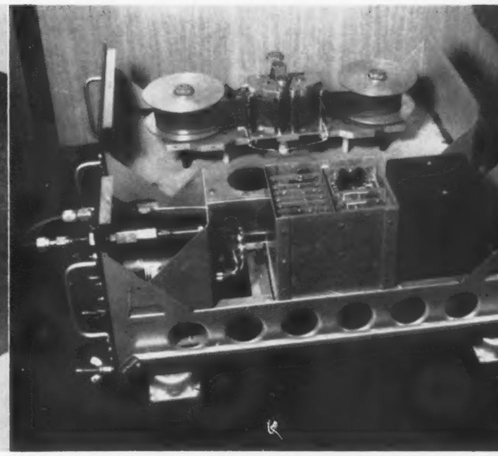
Re-entry Recorder



Printing Bulb



High-Gravity Oscillograph



Flight Recorder

Miniature Printer. For computer output and for weapons-system checkout devices; prints more than 30 characters per sec on 5/16-in. tape; length, 9¼ in; fits 3-in. instrument case. (Illustrated.) **Potter Instrument Co.,** Plainview, N.Y.

Microfilm Catalog File. Contains more than 25,000 catalog pages recorded on 22 reels; information indexed and revised every 4 months. (Illustrated.) **Rogers Publishing Co., Technical Services Div.,** Denver, Colo.

Tape Head and Tape Guide. Model DTH2132 digital magnetic-tape head is a 32-track interlaced head for 1-in. tape; gap length, 10 microinches; Model TG series has tape slot guide to reduce tape curl and wear. **Shepherd Industries, Inc.,** Nutley, N.J.

Tape System. Total storage of 300,000,000 bits achieved on one 6-in. file reel of 1-in. magnetic tape; speeds up to 300 ips; read and write heads available. **Shepherd Industries, Inc.,** Nutley, N.J.

Fast Start-Stop Transport. Digital unit for mobile, shipboard, and airborne applications; capable of 7 or 8 tracks of read/write on ½-in. tape; wt, 80 lb. **Shepherd Industries, Inc.,** Nutley, N.J.

Tape Simulator. For manual entry of data into punched tape systems; capacity of 80 bits of information each, entered by pushbutton; buttons arranged in 10 lines and 8 channels. **Siegler Corp., Hallamore Electronics Co., Div.,** Anaheim, Calif.

Printing Unit. Operates at 600 lines per min; comprised of a tape reader, control unit and printer; functions on the "off-line" principle, freeing the equipment for other computational work. **Sperry Rand Corp., Remington Rand Div.,** New York, N.Y.

Galvanometric Recorders. Flush-mounted "recti/riter" recorders in single- and dual-channel models; illuminated scale; zero adjustment. **Texas Instruments Inc.,** Houston, Tex.

Temperature and Pressure Readout. Digital system reads out from resistance temperature bulbs in the zero to 1400 F range from transducers sensing from zero to 10,000 psi. **Texas Instruments, Inc.,** Houston, Tex.

Tape Reader. Accommodates 5, 6, 7, or 8-hole 1-in. Mylar tape; operates at reading speed of 60 lines or characters per sec; self-stepping, or 50 lines per sec impulse stepping. **Textron Inc., California Technical Industries Div.,** Belmont, Calif.

Transfer System. Transmits up to three channels of analog information with over-all accuracy of 0.5 per cent of full range; resolution 0.006 per cent of full scale at sampling rate of 10 per sec in each channel. **Vitro Laboratories, W. Orange, N.J.**

Optical Systems

Telefold Lens. Uses catadioptic system permitting 42-in. focal length to be folded in 10-in. tube; for objects from 2 ft to infinity; wt, 3 lb. (Illustrated.) **Atlantic Research Corp.,** Alexandria, Va.

Optical-Aids Kit. Fundamental measuring and examination tools; more than 20 optical units may be assembled into optical viewers, surface comparators and microscopes. (Illustrated.) **Bausch & Lomb Optical Co.,** Rochester, N.Y.

Ultra-Speed Camera. Takes from 480 to 1,600,000 pictures per sec on standard 35-mm film; stretches the events of 1 sec into 28 hr; equipped with lighting system. **Benson-Lehner Corp.,** Santa Monica, Calif.

Tracking Camera. Photographs target being tracked by radar; driven by synchronous motor at constant speed of 24 pps; 40- or 80-in. lens; 200- or 400-ft magazine. **Camera Equipment Co.,** New York, N.Y.

KA-30 Aerial Camera. Model KA-30, used in drones and manned vehicles; image motion compensation freezes picture on film by moving film at same relative speed as aircraft. (Illustrated.) **Chicago Aerial Industries, Inc.,** Melrose Park, Ill.

Space Telescope Mirrors. Lightweight mirrors of fused silica for missile, satellite, and airborne telescoping systems; mirror blanks produced in wide range of sizes and shapes. (Illustrated.) **Corning Glass Works,** Corning, N.Y.

Magnetic-Tape System

High-Speed Film. Double-X Panchromatic Negative Film (35 and 16 mm) for photography under adverse lighting conditions; exposure index is daylight 250 and tungsten 200. **Eastman Kodak Co.,** Rochester, N.Y.

Monochromator and Spectrometer. Has available a wide range of prism systems covering the ultraviolet, visible, and infrared regions; can be used as table model. **Engis Equipment Co., Scientific Instruments Div.,** Chicago, Ill.

Super-Farron Lenses. Form image on a surface convex to the objective having a radius of curvature of 4 in. **Farrand Optical Co., Inc.,** New York, N.Y.

Retroflectors. Irrad T-3, a portable transit-time measuring device for use with cooperative targets; has narrow transmitting beam and high degree of security from detection. **Farrand Optical Co.,** New York, N.Y.

Boresight Camera. Model IBDM-20, 35-mmg. designed as a radar-antenna–mounted boresight camera to obtain pictures and data for calibration, tracking-error correction, and documentary use. **Federal Mfg. and Engineering Corp.,** Garden City, N.Y.

Closed-Circuit TV Camera. For missile and other military uses; monitors rocket launchings; requires no auxiliary protective housing; wt, 9 lb. **General Electric Co.,** Communication Products Dept., Lynchburg, Va.

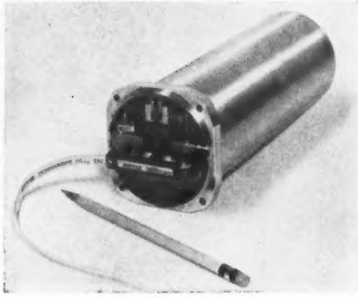
Projector-Printer. Reproduces engineering drawings; projection size varied to print any dimension fom 8½ x 11 in. to 34 x 48 in. **Keuffel & Esser Co.,** Hoboken, N.J.

Theodolite. Designed to American standards; an erected image; automatic indexing of vertical circle; all control knobs on one side; horizontal and vertical circles viewed simultaneously; optical plummet built into the alidade. (Illustrated.) **Keuffel & Esser Co.,** Hoboken, N.J.

Leveling Kit. Optics provide a flat, weightless reference plan; readings to 0.001 in; components include tilting level, optical micrometer, and Wyteface scales; wt in wooden case, 23 lb. **Keuffel & Esser Co.,** Hoboken, N.J.

Comparator. Accommodates plates and films to 10 x 10 in; range, 265 mm in the X-coordinate and 250 mm in the Y-coordinate; direct-reading accuracy to 1 micron. **David W. Mann, Inc.,** Lincoln, Mass.

Radar Viewer. Permits fast visual comparison of a marked reconnaissance radar picture with the current scope image; pictures used are printed on 35-mm film twenty or more frames in length. **Mast Development Co.,** Davenport, Iowa.



Miniature Printer

Microfilm Catalog File

Telefold Lens

Optical-Aids Kit

KA-30 Aerial Camera

Photoelectric Reader. For use in automatic control systems utilizing electronic circuits which operate as a function of reflected light intensity; adaptable to various mountings in limited access areas. **Melpar, Inc.**, Falls Church, Va.

Hand-Held Reflex Camera. Hand-held or tripod-mounted, for field and studio use; 35 mm; variable-disk focal plane shutter operated behind aluminized and coated steel reflex shutter. (Illustrated.) **Mitchell Camera Corp.**, Glendale, Calif.

Paxoramic Lens. High-resolution photo objective, 24 in. focal length, f/6 design; diffraction limited with only some secondary color remaining; requires special film for aerial photography. **Pacific Optical Corp.**, Inglewood, Calif.

Optical Proving Ring. Force-calibration standard; repeatability, 1/20 of 1 per cent of full scale deflection; scales calibrated to 0.00002 in. **Steel City Testing Machines, Inc.**, Detroit, Mich.

Optical Wedge. Method of measuring displacement in vibration testing; pressure-sensitive sticker fixed to flat surface of object under test; two triangles appear when wedge vibrates, and displacement indicates on scale. **Textron Electronics, Inc.**, New Haven, Conn.

Eye-Movement Camera. Records continuous picture of what an observer sees; white dot superimposed on picture shows eye's center of attention. **Westgate Laboratory, Inc.**, Yellow Springs, Ohio.

Oscilloscopes

Cathode-Ray Tube. Type K1931, 5 1/2-in. tube, permits high-frequency operation for general-purpose oscilloscopes and other instruments; operates at 5000 v; useful scan, 4.75 in. **Allen B. DuMont Laboratories, Inc.**, Clifton, N.J.

Low-Frequency. Bandwith of 300 kc at 3 db; sensitivity 10 mv/cm with identical X and Y amplifiers; common-mode rejection better than 100 to 1. **Allen B. DuMont Laboratories, Inc.**, Clifton, N.J.

Fast Oscilloscope. Models 707 and 708 (Milli-Mike) detect and display phenomena lasting only 20 billionths of a sec; bandwidth rated as DC to 2000 mc, usable to 3000 mc. **Edgerton, Germeshausen & Grier, Inc.**, Boston, Mass.

"Sampling." Has rise time of less than 0.7 millimicrosec; sweep times range from 10 to 100 millimicrosec/cm; a magnifier increases the fastest sweep to 0.1 millimicrosec/cm. **Hewlett-Packard Co.**, Palo Alto, Calif.

General-Purpose. Push-pull amplifier; response 3 db from 10 cps to 500 kc and 6 db to 700 kc; 20 mv/in. sensitivity. **Precision Apparatus Co., Inc.**, Glendale, N.Y.

Direct-Writing. Self-contained, single channel; Model 299 with DC amplification; Model 301 with AC carrier amplification; chart speeds of 5 and 50 mm/sec. **Sanborn Co., Industrial Div.**, Waltham, Mass.

Power Supplies

Engine Generator. Diesel-powered; lightweight and hazard free; 7.5-kw static-excited generator; for operation under all natural climatic conditions; wt, 650 lb. **American Marc, Inc.**, Inglewood, Calif.

DC/AC. For missile and other airborne applications; three solid-state units voltages from 5 to 250 v DC in 34 standard models. **Arnoux Corp.**, Los Angeles, Calif.

AC Source. For bench testing alternator control panels, servo-motors, gyros, and AC-measuring equipment; output 100 VA per phase; inherent overload protection. **Avtron Mfg., Inc.**, Cleveland, Ohio.

Regulated. Furnishes power for transistorized electronic devices; input 115 v AC, 400 cycles, single phase; output 28 v DC nominal at 1.5 amp max. **M. Ten Bosch, Inc.**, Pleasantville, N.Y.

Transistorized. Continuously variable output ranges from 0–30 v and 0–200 milliamps at input of 117 v 60 cps; ripple content in output, 0.5 mv peak-to-peak. **Computer Engineering Associates, Inc.**, Pasadena, Calif.

Silver-Zinc Primary. Battery for missile and space vehicle; provides 200 amp at 28 v; maximum current, 400 amp; discharge time, 1.8 min; 20 cells. **Cook Batteries**, Denver, Colo.

Contour Batteries. Configured silver-zinc primary battery for missiles; automatically activated 20-cell unit shaped to an 88-deg arc; wt, 13 lb; capacity 7 amp-hr. Also, 40 cells for 11 kw. **Cook Batteries**, Denver, Colo.

Dual-Battery. In single case; auxiliary power for missiles; two 20-cell sections, one providing 25 amp at 28 v and the other providing 28 v at 46 amp. **Cook Batteries**, Denver, Colo.

Missile Battery. For extremely low anode gassing; capacity 4 amp-hr; average current, 80 amp at 28 v; tank and piston activator provides full current within 1 sec. **Cook Batteries**, Denver, Colo.

Portable. Self-contained; DC output, 35 kv at 1 ma and 30 kv at 5 ma; zero-start interlock; continuously adjustable from 5 to 115%; wt, 60 lb. **Del Electronics Corp.**, Mt. Vernon, N.Y.

Regulated High Voltage. Solid-state; referencing and regulating circuitry accomplished at low voltage; five models with output ratings from 1 kv at 5 ma to 10 kv at 1 ma; sealed construction. **Del Electronics Corp.**, Mt. Vernon, N.Y.

Transistorized. Supplies well-regulated DC at high current; output 10–32 v DC at 0–15 amp, both sides floating with respect to ground. **Del Electronics Corp.**, Mt. Vernon, N.Y.

Noise Diode. Furnishes starting and operating currents to gas-discharge noise diodes; both beam-current and heater-current capacity are 400 ma; wt, 15 lb. **De Mornay-Bonardi**, Pasadena, Calif.

Compact DC. Series of 24 models with inputs of 105–125 v AC, 60–400 cps; outputs 5–50 v DC nominal and 225–750 ma; wt, 3.25 lb. **Dressen-Barnes Corp.**, Pasadena, Calif.

Laboratory. Transistorized; Model 62-150 has DC output of 0.5 to 100 v and 0 to 1 amp; Model 62-151 has DC output of 3 to 100 v and 0 to 3 amp; available from stock. **Dressen-Barnes Corp.**, Pasadena, Calif.

Load Bank. Low retained heat capacity and low surface temperatures; total wattages available up to 15 kw 110 v or 28 v; wt, less than 15 lb. **Electrofilm, Inc.**, N. Hollywood, Calif.

Regulated. Model PS-3, transistorized; filtering circuits keep AC ripple below 1 mv for all conditions; output 0–25 v, 0–200 ma; 0–25 v, 0–100 ma. **Electro Products Laboratories, Inc.**, Chicago, Ill.

Power Packs. Subminiature solid-state, high-voltage DC; for operation from a 60- or 400-cycle line, in addition to a 26–29 v DC line; ripple 1% rms; 1000, 3000, and 5000 v DC at maximum current of 100 ma. **Era Pacific, Inc.**, Santa Monica, Calif.

High-Voltage DC. Model 410A, rated 1–10.01 kv and 0–10 ma; 0.01% regulation; stability 0.005%/hr; ripple less than 5 mv; wt, 95 lb. **John Fluke Mfg. Co., Inc.**, Seattle, Wash.

Precision. For inertial-guidance integration; input 115 v, 400 cps 3-phase 5 w max; 28 DC, 40 ma. max; 28 v DC unregulated, 7.5 w; 8 lb. (Illustrated.) **General Precision, Inc., Kearfott Div.**, Little Falls, N.J.

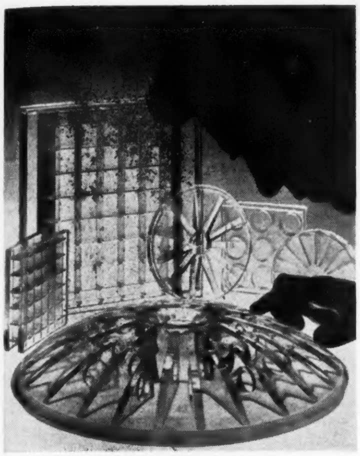
DC Source. For small servosystems, prototypes and test; contains filtered, unregulated full wave bridge DC supply and 2 isolated outputs, 4- and 0.5 w capacity. **General Precision, Inc., Kearfott Div.**, Little Falls, N.J.

Gyro-Wheel Supply. Transistorized; for inertial gyros; standard voltage stability, 0.5 v from 0 to full load of 3 MIG-V gyros and from –55 to 71 C (ambient). **Harrel, Inc.**, New York, N.Y.

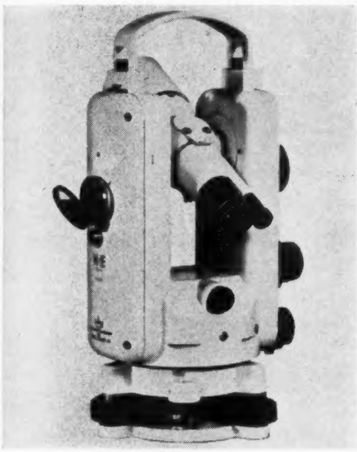
Variable. Zero to 18 v at any current from 0–1.5 amp; regulation for load or line less than 5 mv; ripple below 500 microvolt; low internal impedance. **Harrison Laboratories, Inc.**, Berkeley Heights, N.J.

Power Converter. In the 100–500-w class; transformers layer wound; precise control of voltage "spikes" which can cause destruction of switching transistor. (Illustrated.) **Hoover Electronics Co.**, Timonium, Md.

Battery Chargers. Line of silicon battery chargers with automatic stepless control for



Space Telescope Mirrors



Theodolite

lead-acid and nickel-cadmium types; operate from single-phase power; capacities, 1 and 3 amp. **Hughes Electronics Co.**, Los Angeles, Calif.

Triple Outputs. Finely regulated DC outputs –28 v DC at 2.5 a, 120 v at 250 ma, and 250 v DC at 500 ma–from single 70-lb unit; input 110-130 v AC. **Hydro-Aire Co.**, Burbank, Calif.

Power Unit. Compact 50-kw combination motor generator and control unit for high-frequency induction melting; requires 60 cy 440- or 220-v power connection and a water drain. **Inductotherm Corp.**, Delanco, N.J.

Convection-Cooled. Blowerless, solid-state-regulated power supply includes 5-amp unit 3.5 in. high in standard rock mount; wt, 55 lb. **Lambda Electronics Corp.**, College Point, N.Y.

Airborne. Supplies stable source of DC power for instrumentation, telemetering and recording systems; 5, 10, or 15 v DC. **Magnetic Research Corp.**, Hawthorne, Calif.

Power Isolator. Provides output isolated from line voltage and ground line; loading of output to ground less than 2 uuf capacitance and greater than 50,000 megohms. **Moeller Instrument Co., Inc., Electronics Div.**, Richmond Hill, N.Y.

Power Conversion. Rotary unit converts 440 v 3-ph 60 cy AC power into 45 kw of precise 28 v DC; in range of 25-29 v, voltage will not vary ±5%. **Motor Generator Corp.**, Troy, Ohio.

High Power-to-Volume Ratio. Output of 0-36 v and 0-4 amp either positive or negative; may be floated up to 500 v peak above or below ground; input of 105-125 v, 55-65 cps. **NJE Corp.**, Kenilworth, N.J.

Ground-Support. DC power supply with output of 22-33 v at 50 a; 70% efficiency at 28 v and 25-50 a; ripple less than 5% rms; meets MIL specs. **Perkin Engineering Corp.**, El Segundo, Calif.

Turbojet Starter. Delivers 28 v at 1400-1500 amp for first 3-5 sec; 28 v at 1000-1200 amp for next 3-5 sec; 28 v at 1000 amp continuous duty. **Perkin Engineering Corp.**, El Segundo, Calif.

Militarized DC. Output 28 v at continuous-duty rating of 7.5 amp; features magnetic-amplifier regulation with no vacuum tubes or moving parts. **Perkin Engineering Corp.**, El Segundo, Calif.

Shipboard DC Supply. Output 28 v at 50 amp; automatic current limiting; input 440 v AC, 3-phase, 60 cps; ripple 2% rms. **Perkin Engineering Corp.**, El Segundo, Calif.

Missile Ground Support. Weatherproof DC power supply with output of 24-32 v at 100 amp; regulation is ±0.5% line and load combined. **Perkin Engineering Corp.**, El Segundo, Calif.

Laboratory. Automatic current-limiting circuit and precision voltage regulation; short-circuit current can be selected (40, 100, 200, and 350 ma) on front panel. **Power Instruments Corp.**, El Segundo, Calif.

Welding Control. For "spike power" welding; system uses a coaxial ignitron tube contactor capable of handling very high peak currents for short periods. (Illustrated.) **Robotron Corp.**, Detroit, Mich.

Power-Signal Generator. Frequency range, 275-2750 mc; max output power, 20 w; for low output position, an attenuator of 80-db range is available. **Rohde & Schwarz**, Passaic, N.J.

Instantaneous Switching. Adaptable to satellite tracking stations; switches from AC to battery; output adjustable from 130-160 v, 100 milliamps DC. **R. S. Electronics Corp.**, Palo Alto, Calif.

Magnetically Regulated. Circuits minimize effects of line variations; output, 12 v regulated 60 cps; input, 115-v cps unregulated line. **Schaevitz Engineering**, Pennsauken, N.J.

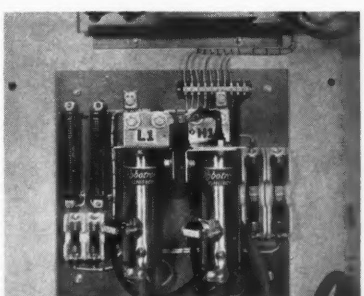
Sealed Battery Cells. Storage bank of 28 cells used in 26-in. payload space-probe sphere to operate radio transmitters. **Sonotone Corp., Elmsford, N.Y.**

Compact DC Supply. Dual output up to 150 ma at ±18 v, or a single output at ±36 v; line and load regulation, ±1% with less than 6 mv of ripple. **Solidyne**, La Jolla, Calif.

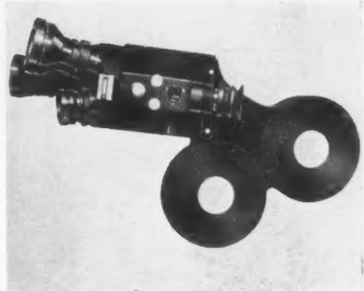
Traveling-Wave Tube. Furnishes all voltages required for operating traveling wave tubes; beam control bias and one or more magnet DC and heater AC voltage supplies; output, 0-4000 v DC at 1 amp. **Sorensen & Co.**, S. Norwalk, Conn.

Rectifier Stacks. Standard assemblies available using Styles 21 and 33 diodes; bridge assemblies use Style 21 diodes rated up to 39 amp single phase and 58 amp 3-phase. **Syntron Co.**, Homer City, Pa.

Transistorized. Delivers variable and fixed outputs from 1.5 to 5 v DC and 2 to 5 amp with

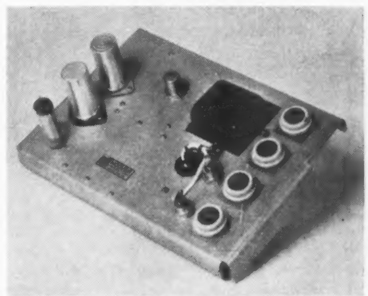


Welding Control



Hand-Held Reflex Camera

Precision Power Supply



Power Converter

high line and load regulation. **Valor Instruments**, Gardena, Calif.

Fail-Proof Power. Instantaneous electronic lock-out with automatic reset featured in twin power supply; two outputs, each 6-30 v DC at 0.5 amp; input 105-125 v, 60-400 cps. **Valor Instruments**, Gardena, Calif.

Isolated Strain Gauge. Model SR 150 output is floating at an impedance of less than 0.2 ohm; noise to ground is less than 10 microvolts peak-to-peak. **Video Instruments Co.**, Santa Monica, Calif.

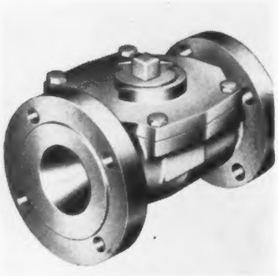
Regulated DC. Input of 100 to 130 v, 50 to 2000 cps; temperature stabilization; output of 12 v DC at 1 amp over range of –25 to 45 C. **Viking Industries, Inc.**, Canoga Park, Calif.

Valves

Two-Way Flow-Ball. May be disassembled and serviced without removal from line; temp range, –20 to 400 F; pressures from vacuum to 300 psi. (Illustrated.) **Hydromatics, Inc.**, Livingston, N.J.

Low-Temperature Solenoid. Controls 3200-psi helium at –280 F from Atlas' powerplant; compensating coil limits power input at –320 F. **IMC Magnetics Corp.**, PSP Engineering Div., Maywood, Calif.

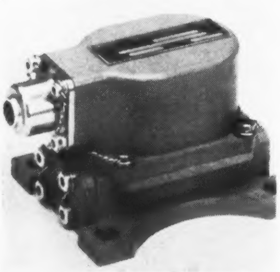
Explosive-Actuated. Service pressure of 300 psi; flow factor of 0.18; operating voltage range, 18 to 30 v DC; temp range, –65 to 160 F; wt, 0.4 lb; metal bottle capacity, 130 cu. ft. **Walter Kidde & Co.**, Belleville, N.J.



Two-Way Flo-Ball

Pressure Controllers. Incorporates DC amplifier weighing 2 lb. and requires 3.5-watts input at 115 v, 60 cycles, 1 phase; output current of ±4 ma; set point control commands desired pressure. **Micro-Gee Products, Inc.,** Culver City, Calif.

Electrohydraulic Servovalve. Subminiature; features nozzle-flapper hydraulic amplifier and mechanical feedback; wt. $^5/_{12}$ oz. (Illustrated.) **Moog Servocontrols, Inc.,** E. Aurora, N.Y.



Electrohydraulic Servovalve

DC Solenoid. For hydraulic, pneumatic, and exotic-fuel applications; operates at 150 psi and may be modified to operate up to 500 psi. **On Mark Couplings, Inc., Los Angeles, Calif.**

Sliding-Gate Regulator. Model 760, for steam, water, oil, air, gas, and corrosive chemicals; stainless-steel body; for pressures to 300 psi; handles pressure drops to 250 psi; body sizes $^1/_2$ to 2 in. **OPW-Jordan, Cincinnati, Ohio.**

Normally Closed, Explosive-Actuated. Zero leak; rated 4200 psi; temp range of −65 to 160 F; flow passage $^5/_{32}$ in; wt 2.6 oz. **Pyronetics,** Santa Fe Springs, Calif.

Pinch-Type. Solenoid-operated for metering, sampling, or "on-off" control of corrosive fluids, slurries, or dry powder; sizes up to 1 in; wt, 4.5 lb. **RKL Controls, Inc.,** Hainesport, N.J.

Metering. Three-port valve with two ports in common, globe valve, or angle valve; stainless steel; $^3/_{16}$-in. flow passage; temp range of −65 to 250 F; wt, 1.06 lb. **Robbins Aviation, Inc.,** Los Angeles, Calif.

Differential Relief. Zero-leak unit for ground-support equipment; holds helium and other gases for long periods with no leakage. Inlet $^1/_2$ in; outlet $^3/_4$ in; handles pressures to 6500 psi. **Vinson Engineering & Sales Corp.,** Van Nuys, Calif. ♦♦

Standards for Calibrating Shock, Vibration Pickups

"Methods for Calibration of Shock and Vibration Pickups" has been approved and published by the American Standards Assn., and is available from its offices—Dept. PR 170, 10 E. 40 St., New York 16, N.Y.—at $2.50 per copy.

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